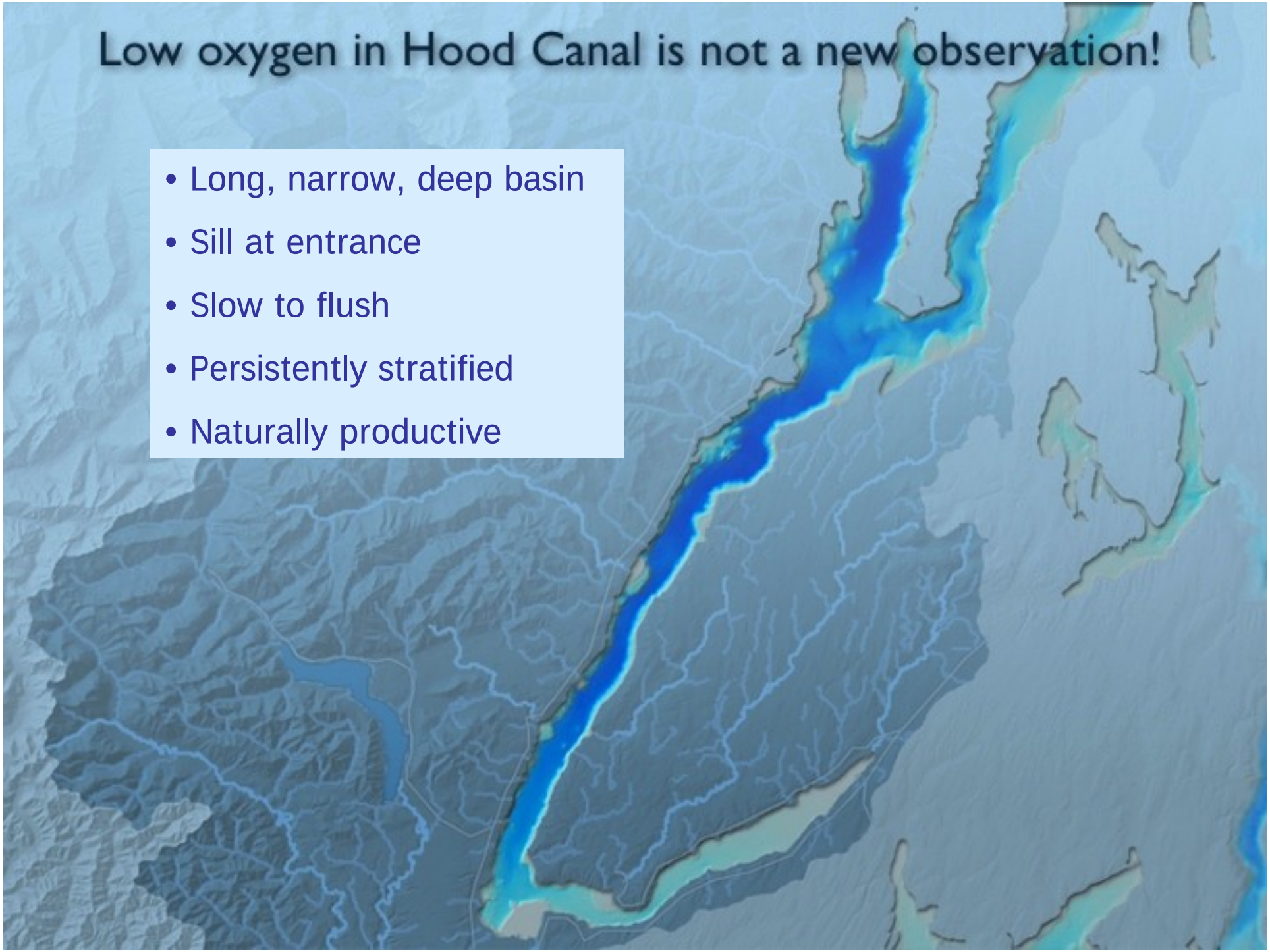
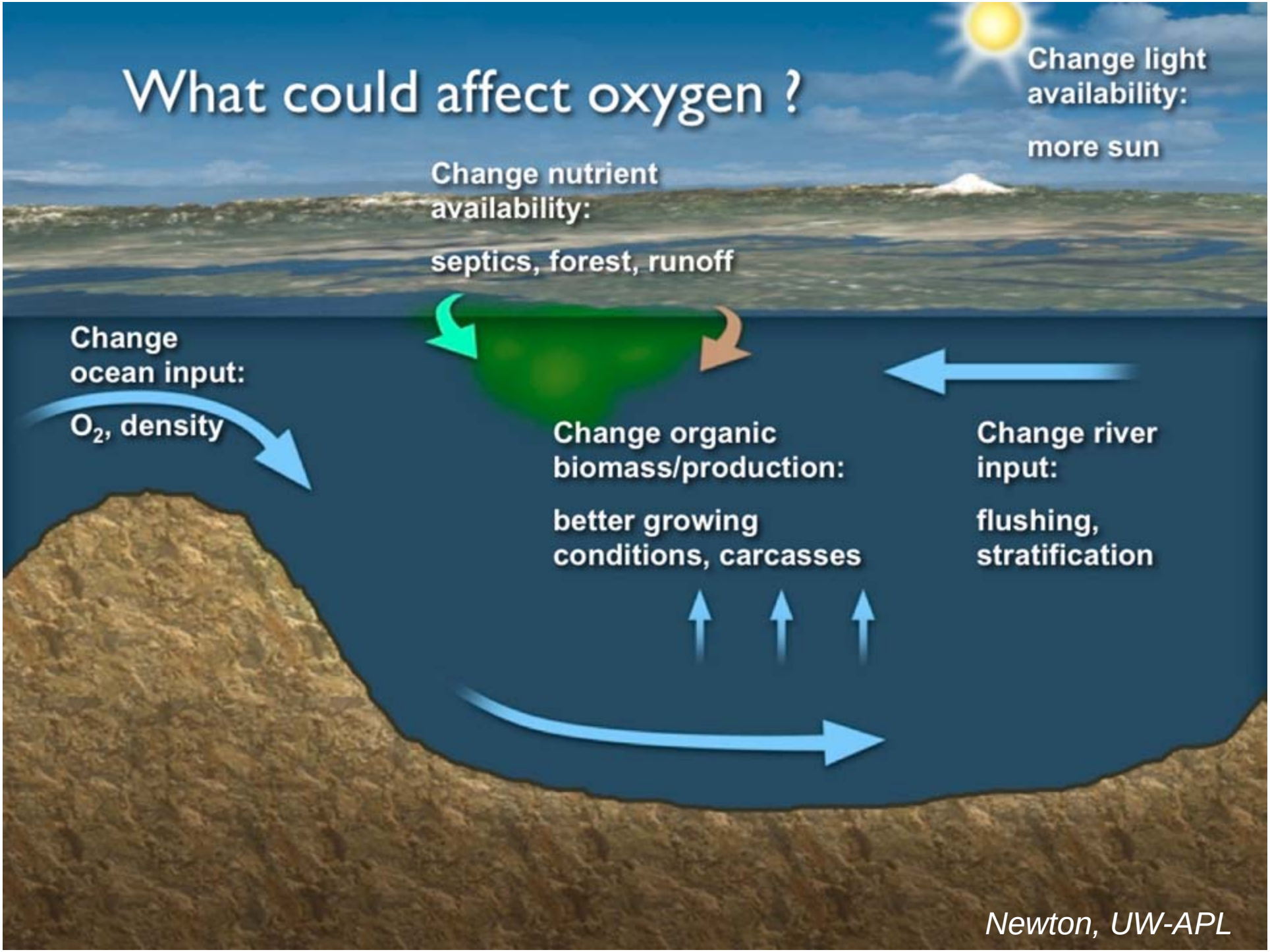
Hood Canal Dissolved Oxygen Program's Integrated Assessment and Modeling Study

What we did,
what we learned, &
why it matters


Low oxygen in Hood Canal is not a new observation!
• Long, narrow, deep basin
• Sill at entrance
• Slow to flush
• Persistently stratified
• Naturally productive


What could affect oxygen ?
Change light availability:
more sun
Change nutrient availability:
septics, forest, runoff
Change ocean input:
O_2, density
Change organic biomass/production:
better growing conditions, carcasses
Change river input:
flushing, stratification
Newton, UW-APL

What we did

IAM Research Strategy

HCDOP Integrated Assessment and Modeling (**IAM)** is a scientific study on the cause for the decline in oxygen in Hood Canal and the efficacy of potential corrective and mitigative actions.

www.hoodcanal.washington.edu

IAM Research Strategy

- Optimize **monitoring and observations**
  - Evaluate nutrient **loading** to canal
  - Better constrain **flushing** estimates
  - Evaluate **climate & ocean effect**
  - Understand **biota** sensitivities

- Use computer **modeling**
  - Run “what-if” scenarios to evaluate hypoxia causes and potential **corrective actions**

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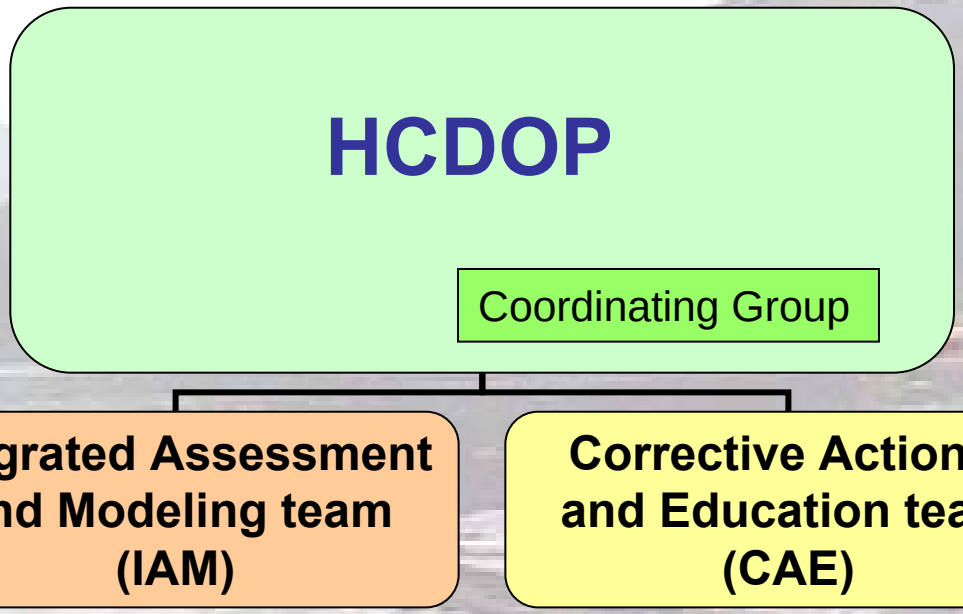
Hood Canal Dissolved Oxygen Program

Structure:

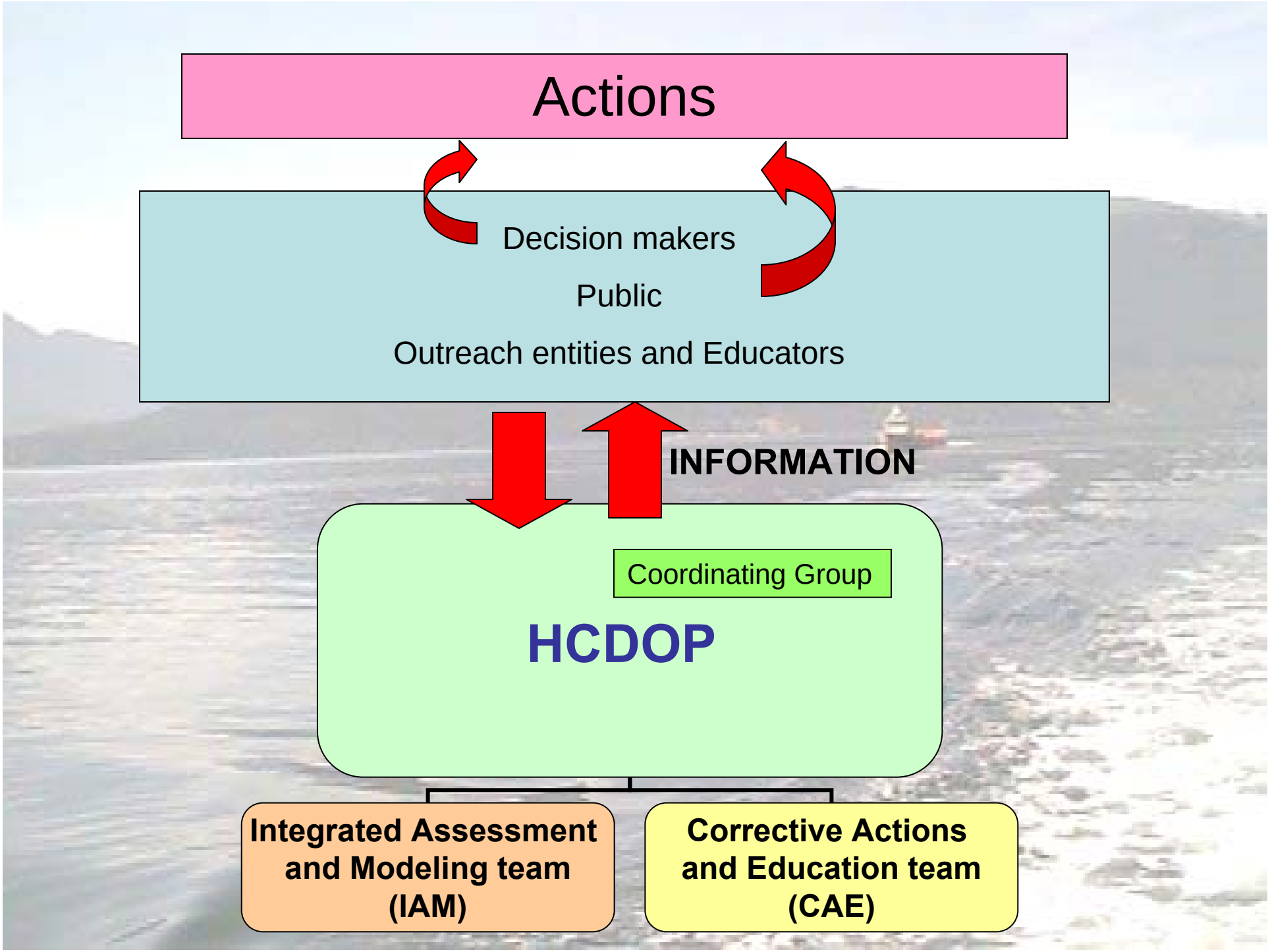


SCIENCE STUDY ON LOW DO CAUSE AND POTENTIAL CORRECTIONS

- Establish automated marine buoys and weekly salt water sampling
- Establish automated stormwater samplers and coordinate river sampling
- Measure N loads to Hood Canal
- Study food-web and biota
- Evaluate using computer models

CORRECTIVE ACTIVITIES, INPUT TO POLICY, AND PUBLIC OUTREACH

- Remove salmon carcasses
- Plan for sewer systems
- Evaluate alternative septic technologies
- Establish anaerobic digester to reduce organic load to Hood Canal
- Enhance and coordinate education and public involvement efforts.


Actions
Decision makers
Public
Outreach entities and Educators
INFORMATION
Coordinating Group
HCDOP
Integrated Assessment and Modeling team (IAM)
Corrective Actions and Education team (CAE)

Hood Canal Dissolved Oxygen Program

The HCDOP Coordinating Group
– coordinating the science and solutions –

Integrated Assessment and Modeling

Partners in Science

- Hood Canal Salmon Enhancement Group
- Jefferson Conservation District
- Kitsap County Health District
- Mason Conservation District
- Mason County Department of Environmental Health
- National Oceanographic and Atmospheric Administration
- NANOOS (Northwest Association of Networked Ocean Observing Systems)
- Northwest Indian Fisheries Commission
- Pacific Northwest National Laboratory
- Pacific Shellfish Institute
- Port Gamble S'Klallam Tribe
- Puget Sound Action Team/Puget Sound Partnership
- PSMEM (Puget Sound Marine Environmental Modeling)
- PRISM (Puget Sound Regional Synthesis Model)
- Skokomish Tribal Nation
- U.S. Army Corps of Engineers
- U.S. Environmental Protection Agency
- U.S. Fish & Wildlife Service
- U.S. Geological Survey
- U.S. Navy
- University of Puget Sound
- University of Washington–Applied Physics Laboratory
- University of Washington–School of Aquatic and Fishery Sciences
- University of Washington–School of Oceanography
- Washington Department of Ecology
- Washington Department of Fish & Wildlife
- Washington Department of Health
- Washington Department of Natural Resources
- Washington Sea Grant Program–University of Washington
- Western Washington University
- WRIA 16 Planning Unit

Corrective Action and Education

Partners in Solutions

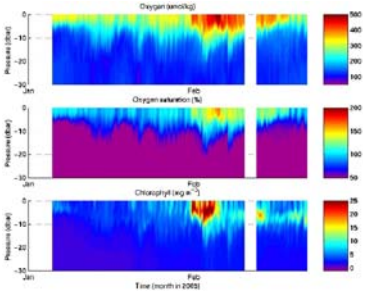
- Hood Canal Coordinating Council
- Hood Canal Watershed Education Network
- Jefferson County Government
- Jefferson County Public Health Department
- Kitsap County Government
- Kitsap Health District
- Lower Hood Canal Watershed Coalition
- Mason Conservation District
- Mason County Department of Environmental Health
- Mason County Government
- Mason County Public Utility District #1
- Pacific Northwest Salmon Center
- Paladin Data Systems
- People for Puget Sound
- Port Gamble S'Klallam Tribe
- Puget Sound Action Team/Puget Sound Partnership
- Shorebank Enterprise Cascadia
- Skokomish Tribal Nation
- U.S. Environmental Protection Agency
- Washington Department of Ecology
- Washington Department of Fish and Wildlife
- Washington Department of Health
- Washington Department of Natural Resources
- Washington Sea Grant Program
- Washington State Parks and Recreation
- Washington State University Extension

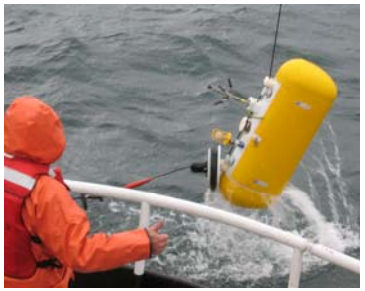
HCDO$_2$P

Hood Canal Dissolved Oxygen Program's Integrated Assessment and Modeling Study

To date:

- Established remote automated monitoring of Hood Canal marine waters and watershed
- Established survey networks, largely from locals, HCSEG, Skokomish Tribe
- Conducted studies on Hood Canal biota and food web energetics
- Applied computer models to Hood Canal marine waters and watershed, linked with atmospheric model output





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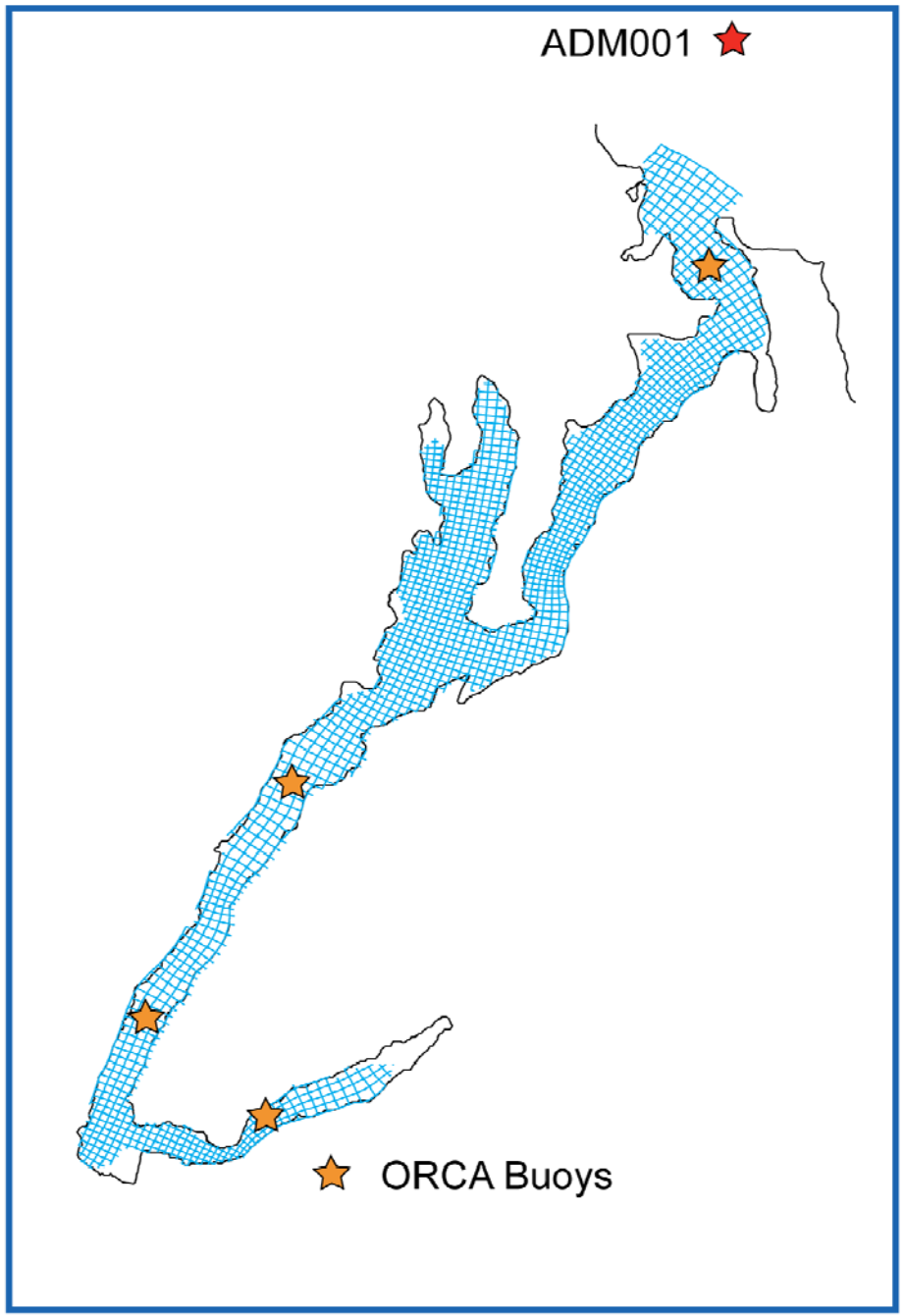


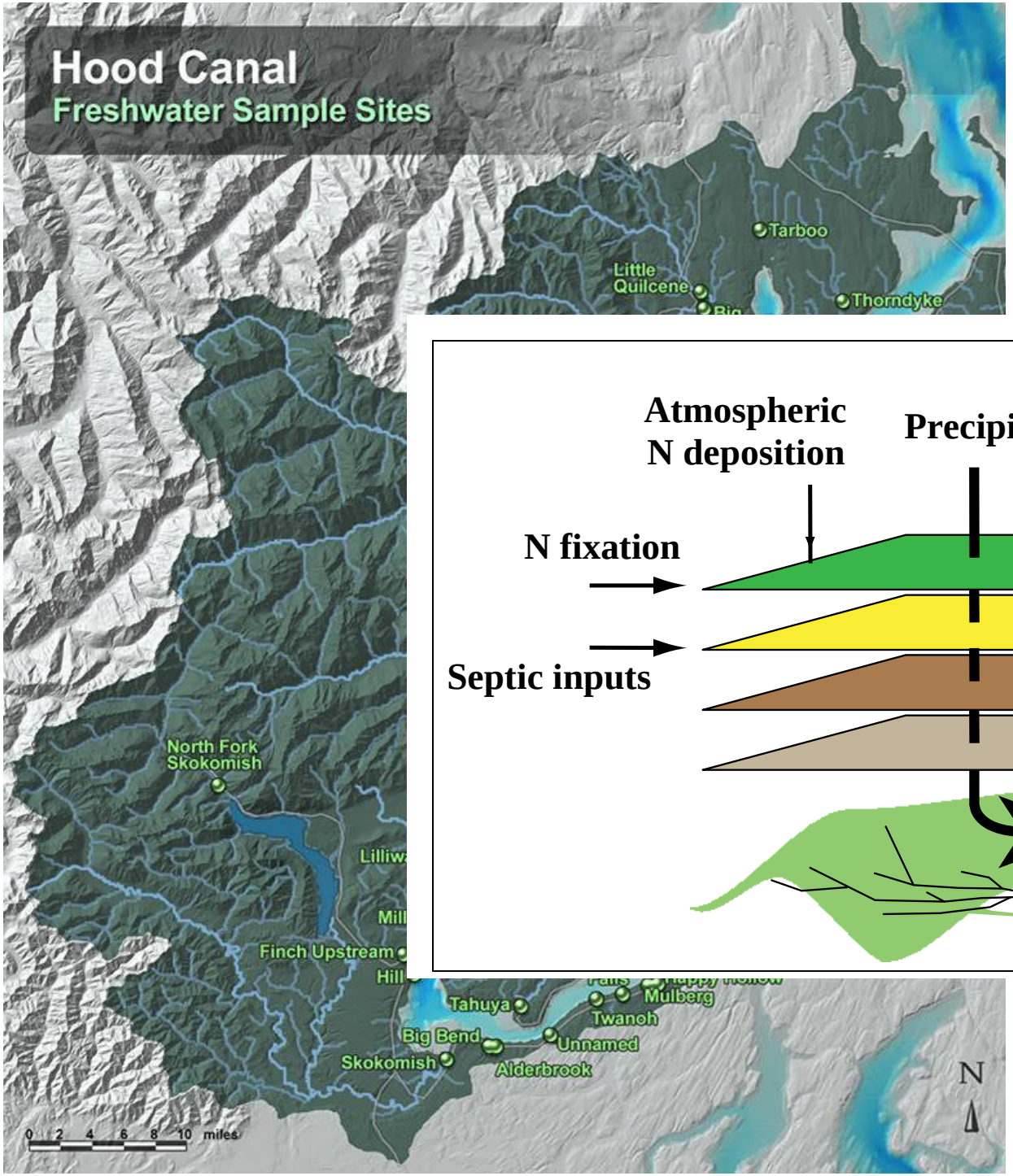
Marine

Sampling by:

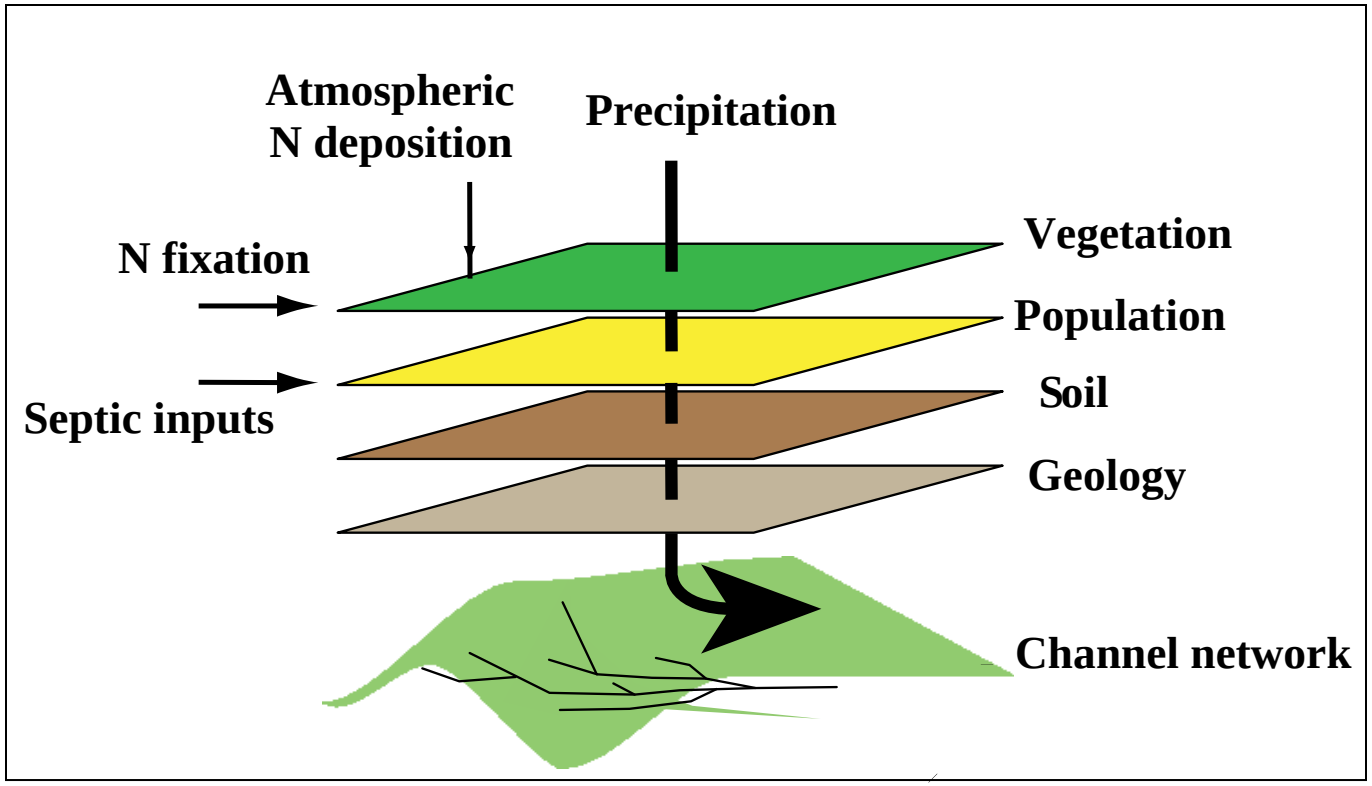
- University of Washington
  PRISM, APL
- Hood Canal Salmon
  Enhancement Group
- Skokomish Tribe
- Port Gamble S'Klallam Tribe
- HCDOP Citizen Monitoring
- WA Dept of Ecology
  PSAMP

Modeling by:

- University of Washington
  PRISM
- USGS

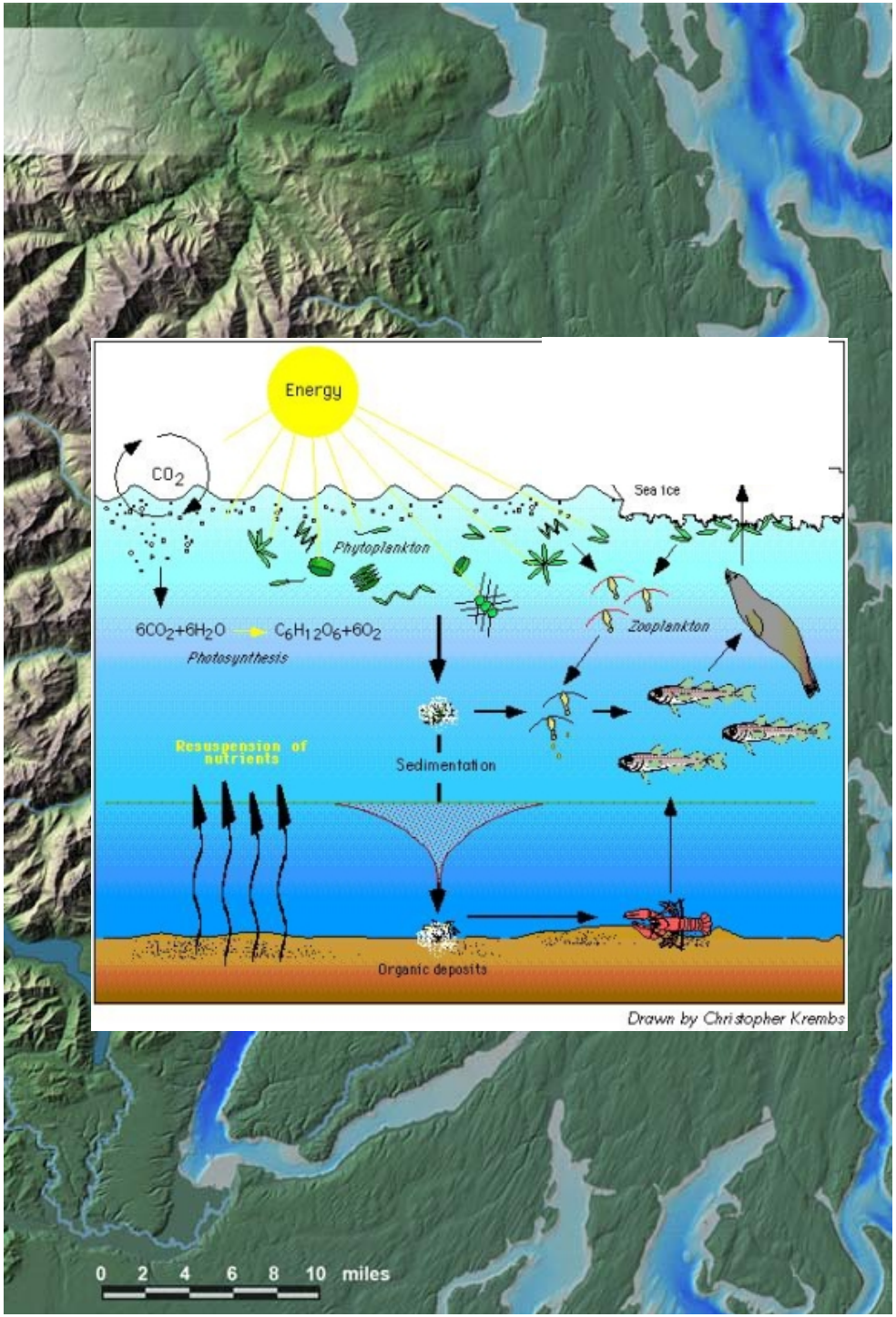


Watershed



Modeling by:

- **University of Washington**
  PRISM



Biota

Sampling by:

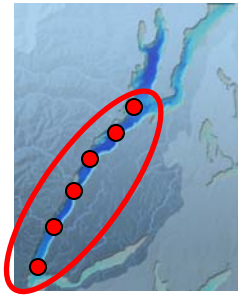
- **University of Washington**
  APL, Oceanography, SAFS
- **Hood Canal Salmon**
  Enhancement Group
- **Department of Ecology**
- **Skokomish Tribe**
- **Port Gamble S'Klallam Tribe**
- **Western Washington University**
- **Pacific Shellfish Institute**
- **USGS**
- **University of Puget Sound**
- **WDNR**
- **WDFW**
- **Battelle**
- **Northwest Indian Fisheries Comm.**

Modeling by:

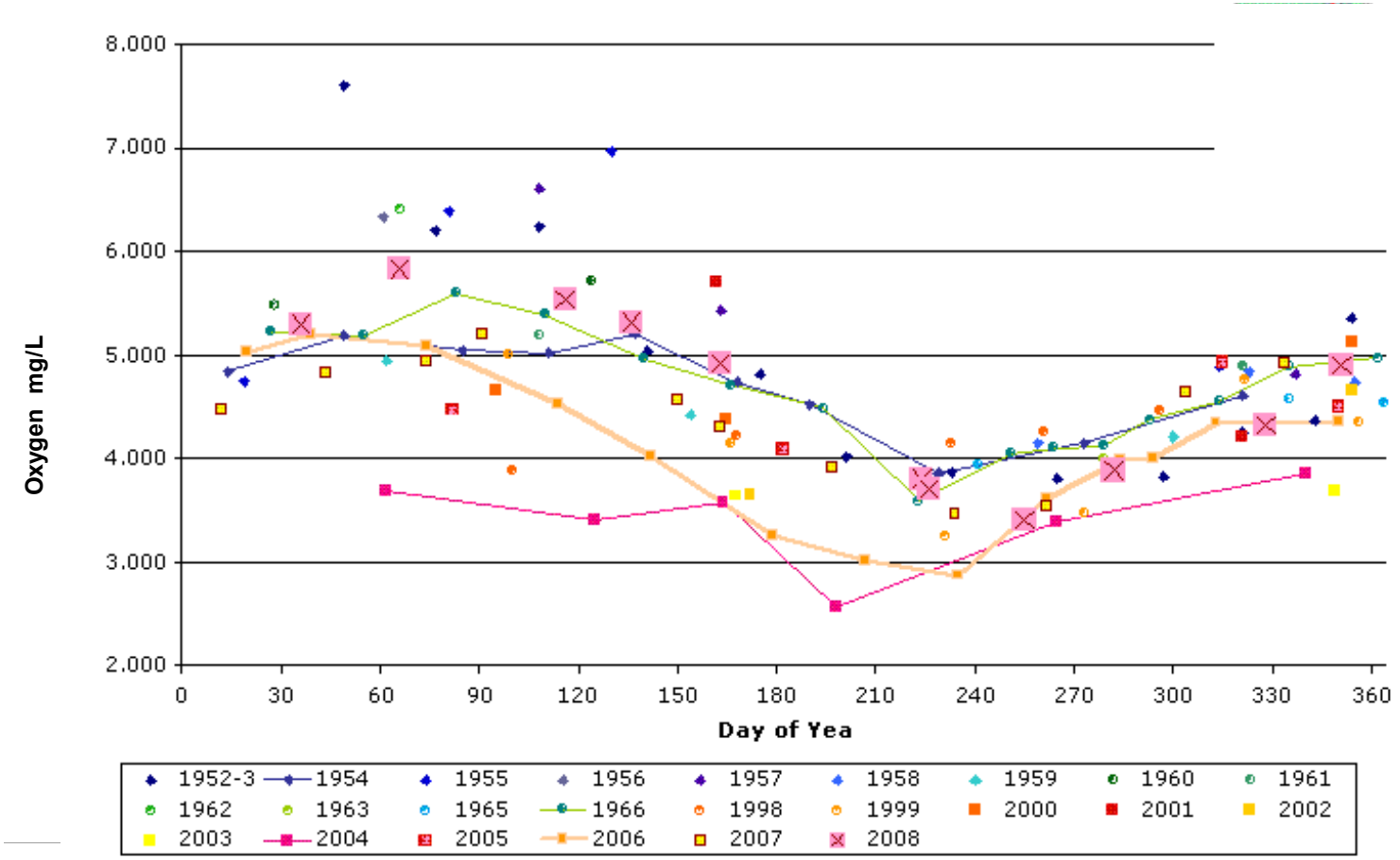
- **University of Washington**
  SAFS

What we learned

Hood Canal Mainstem Oxygen Inventory



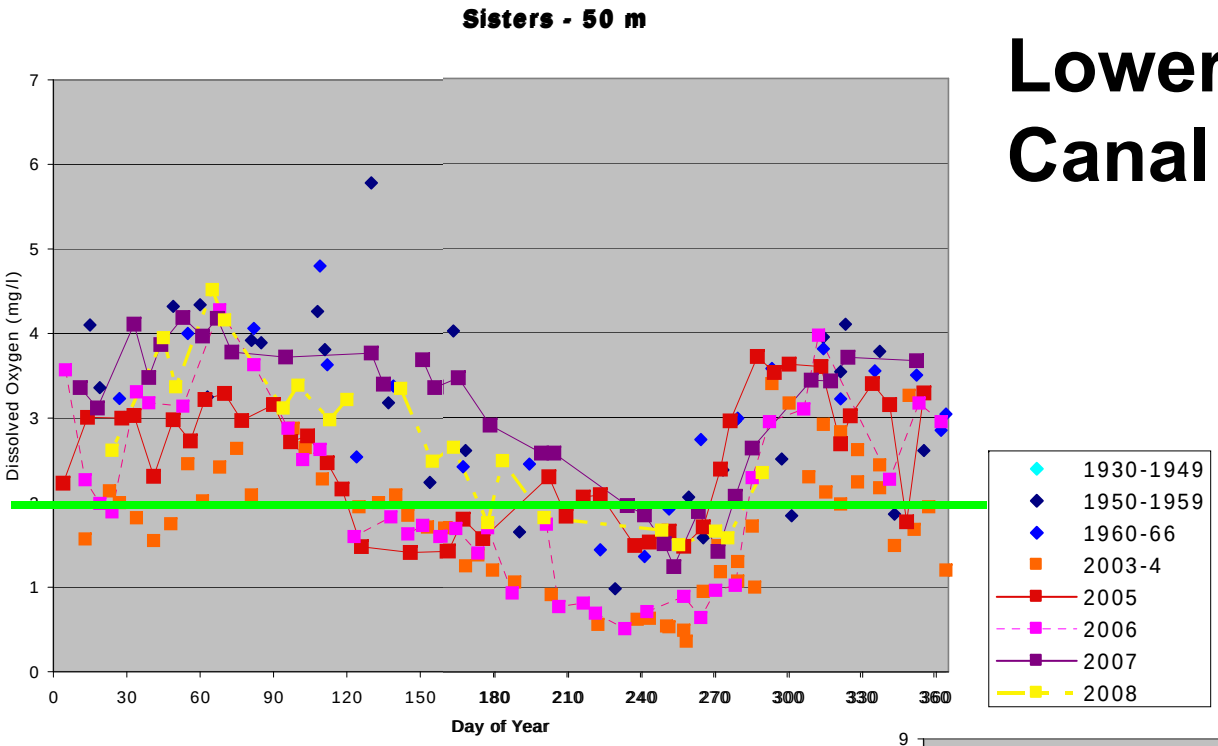
average of the integrated oxygen below 20 m for these six stations



Warner (UW) analysis, Collias (UW) and HCDOP data

Lower Hood Canal Oxygen

Citizen Monitoring Program compared to historical UW Collias database

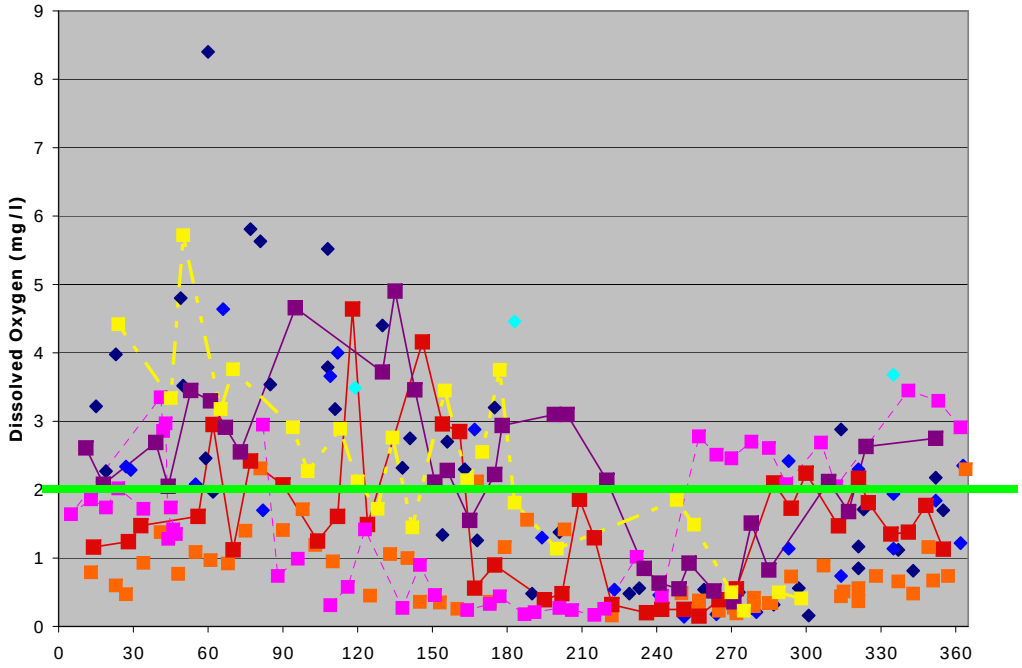


Mean 1952-1966 = 3.23 mg/L

Mean 2003-2007 = 2.27 mg/L

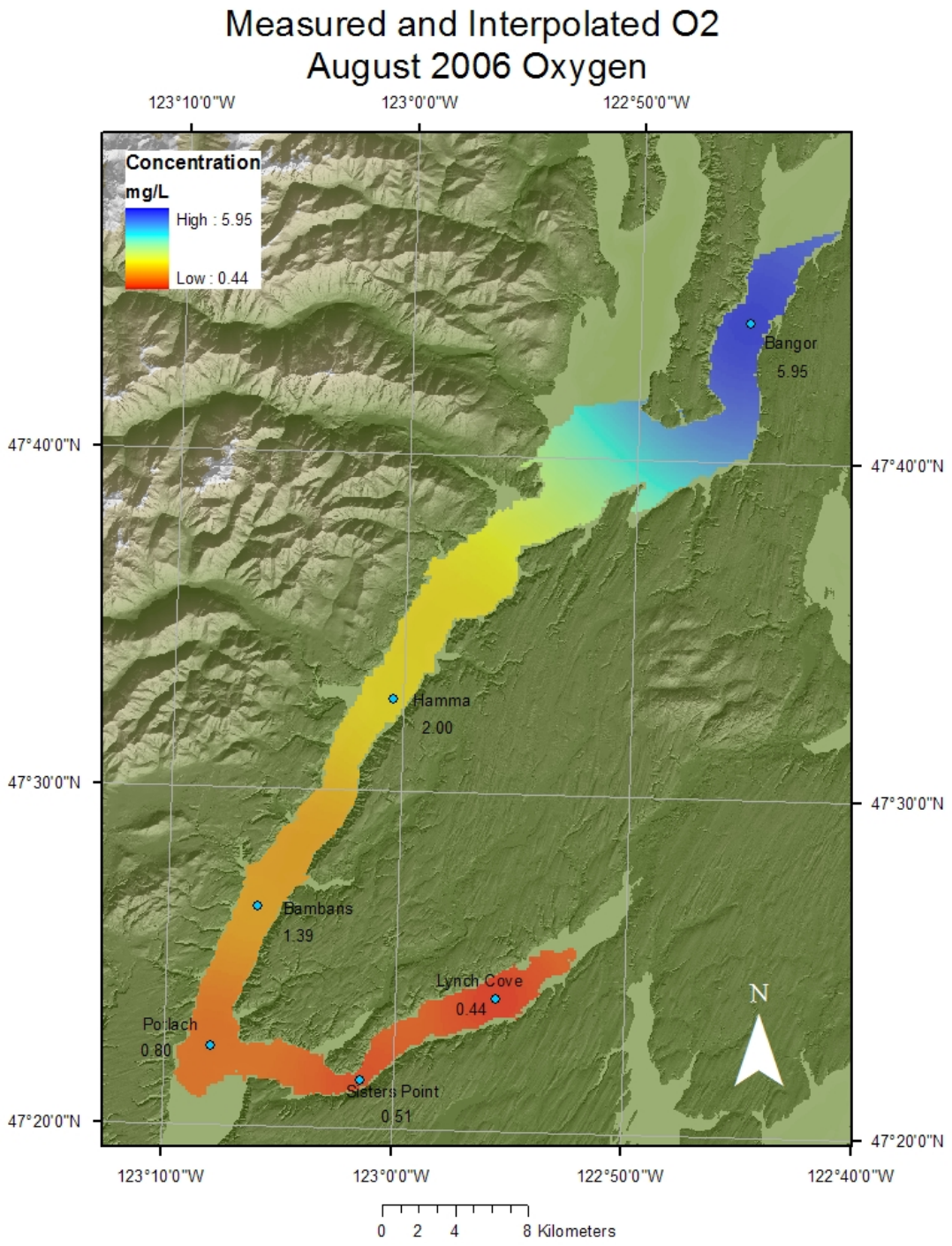
Palsson (WDFW) for rockfish:

2 mg/L is the DO that induces avoidance, 0.7 mg/L is probably the lethal zone



Chronic Oxygen Stress

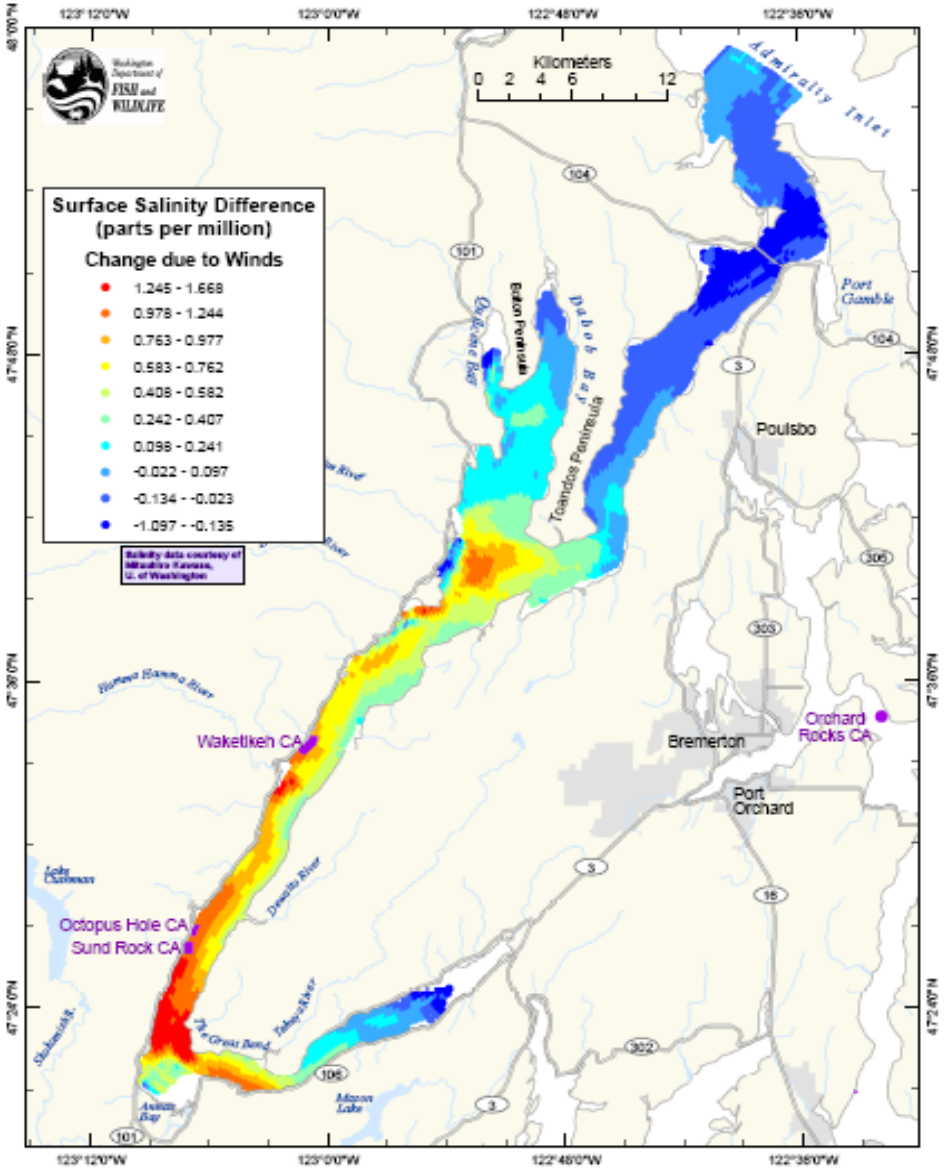
- Areas where risk of exposure to chronically low oxygen is greatest.
- Intensity of red indicates where lowest oxygen concentrations are found, based on August 2006 measurements reflecting the typical pattern.
- This indicates where highest risk of biota stress and mortality due to chronic exposure to low oxygen occurs.

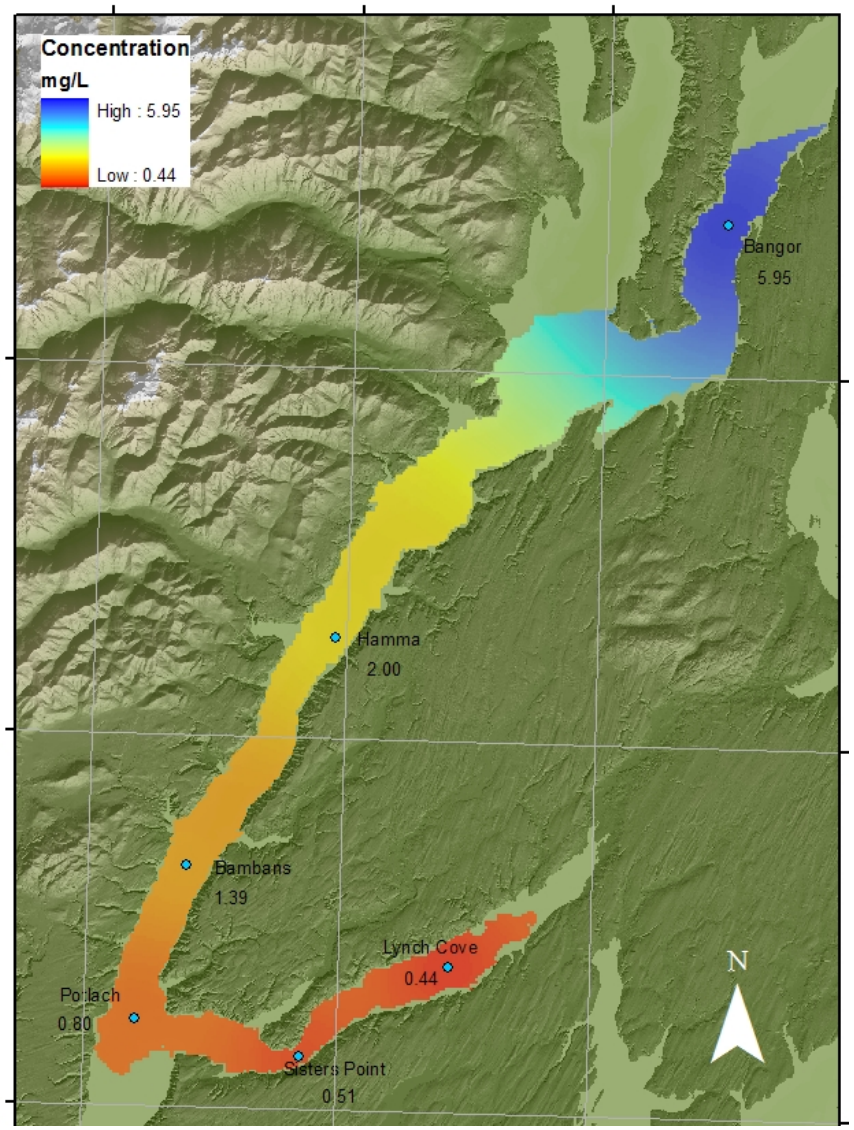


HCDOP IAM data, UW projection

episodic

chronic





Recipe for a fish kill event

	2003	2004	2005	2006	2007	2008
	Fish kill	**Odd activity**		**Fish kill**		
S winds	X	X		X	X	
Low DO	X	**X**	x	**X**	x	x
Shallow/ weak density gradient	X			X		

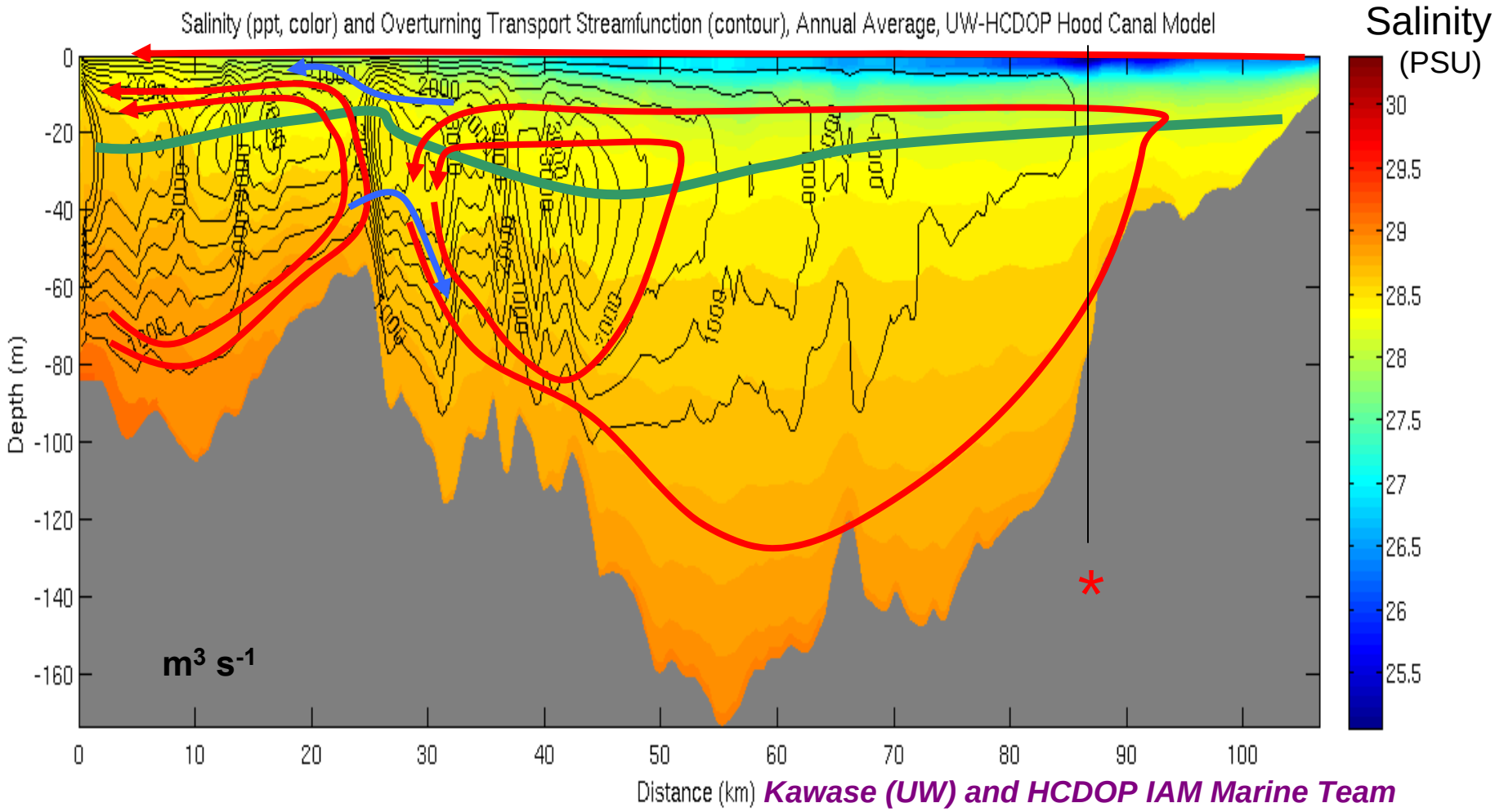
Factors for low oxygen

- Ocean conditions: boundary density, oxygen, nutrients
- Slow flushing (ocean, wind, etc.)
- Climate: early winter-spring transition, weak and northerly winds
- Climate: sunny summer
- Much nitrogen loading

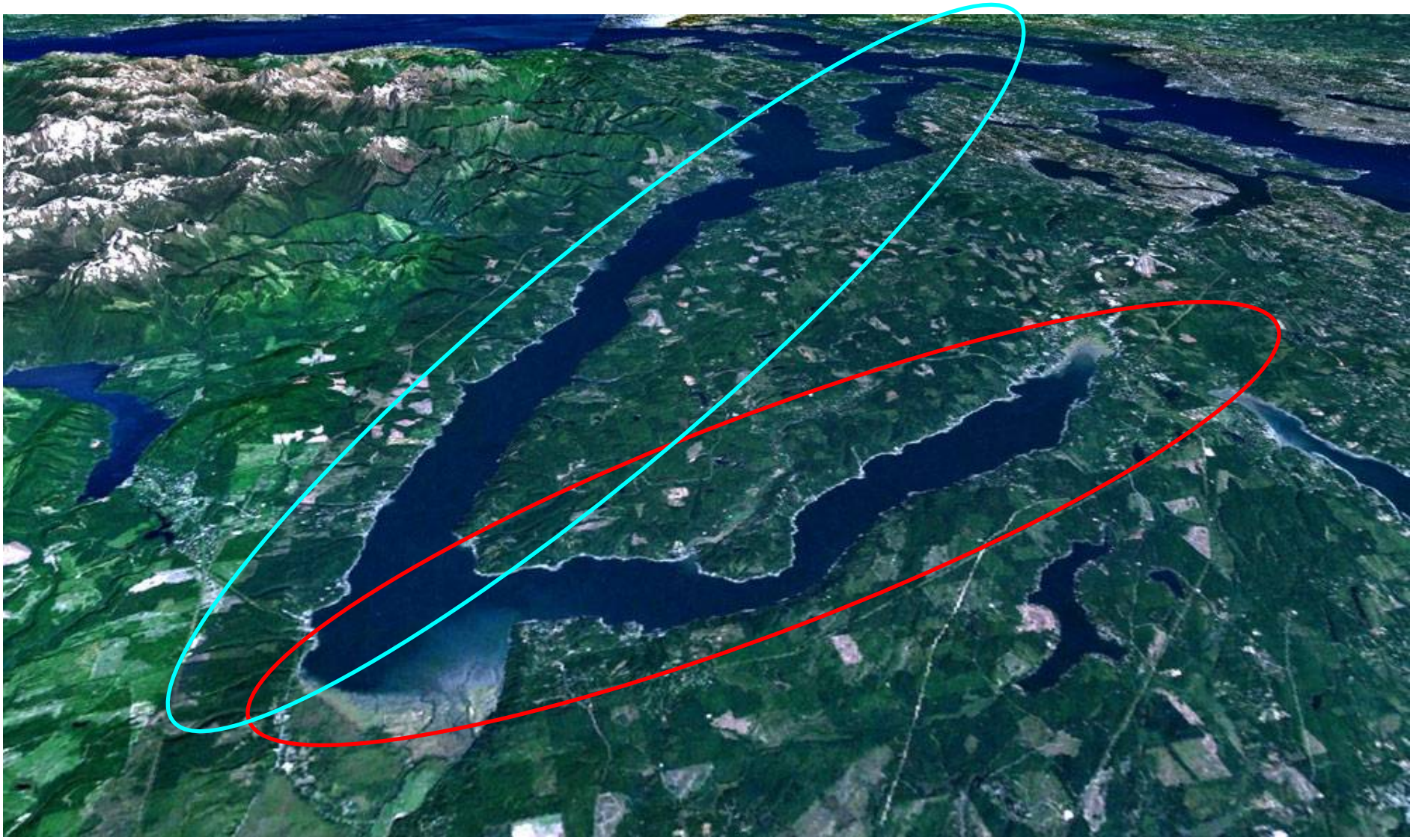
Marine Circulation:

1. some of the N coming over the sill into HC upwells in N Hood Canal, never reaching Lower Hood Canal

2. 25-45% of the N coming to Hoodsport goes back out without fertilizing algae in Lower Hood Canal sunlit surface layer*



Kawase (UW) and HCDOP IAM Marine Team

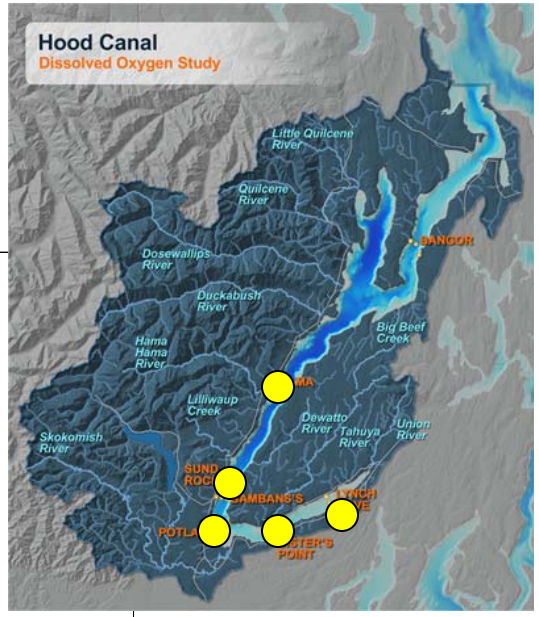


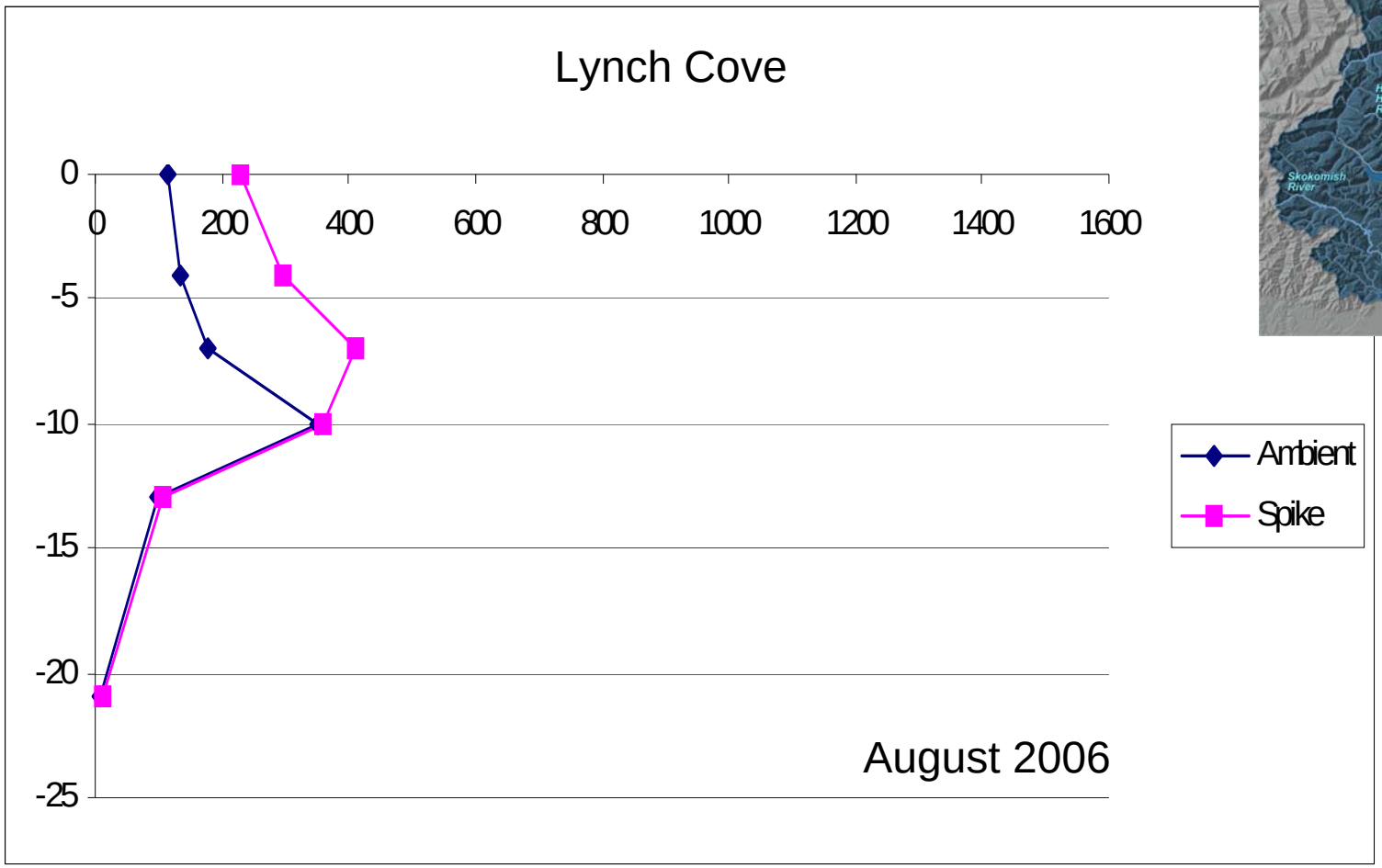
Lower Hood Canal

Hood Canal Mainstem

NOAA

Phytoplankton Production is significantly enhanced by addition of exogenous nitrogen



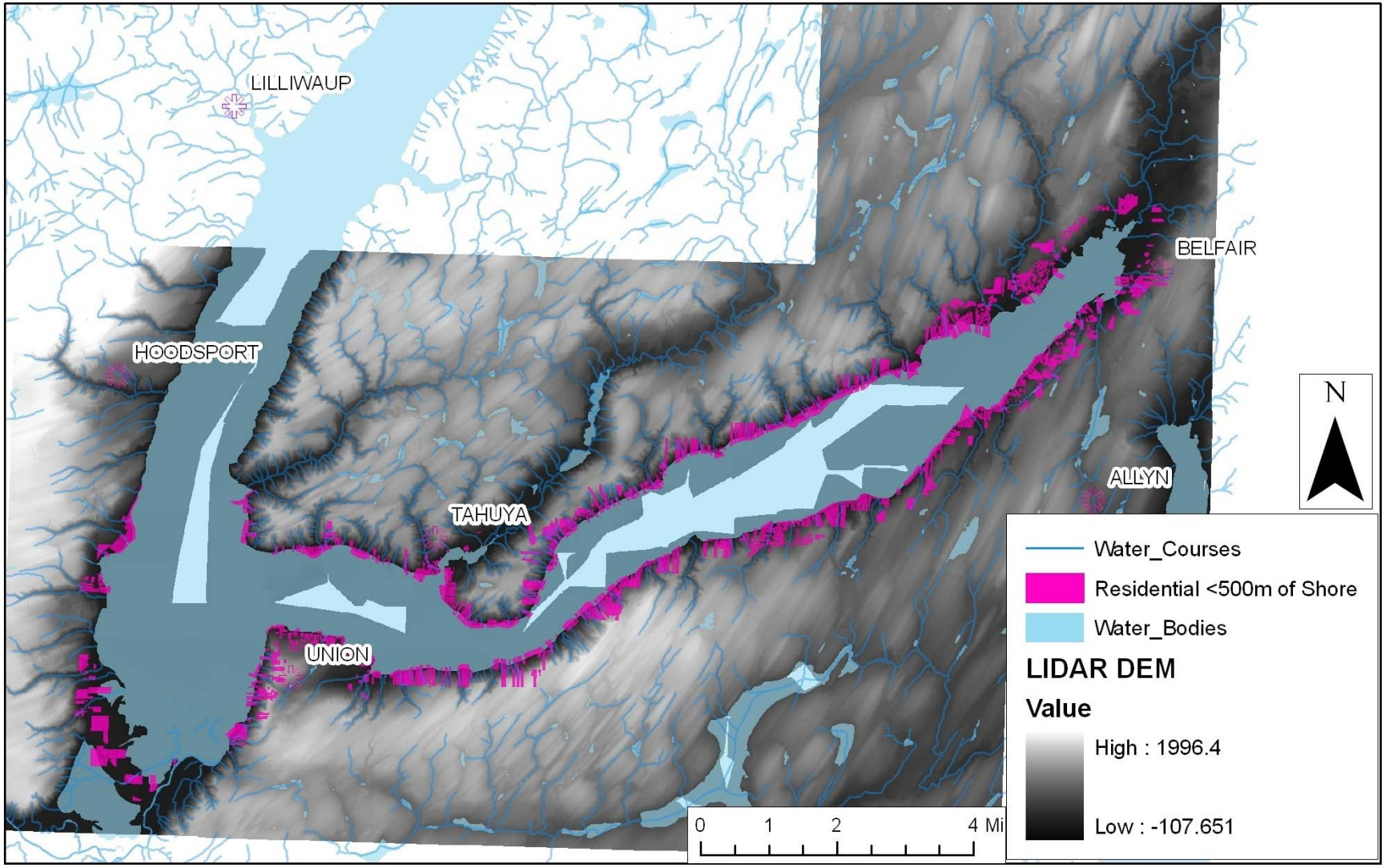


Summertime integrated production increased 20-59%, mean 37%, from added nitrogen spike

Newton, UW

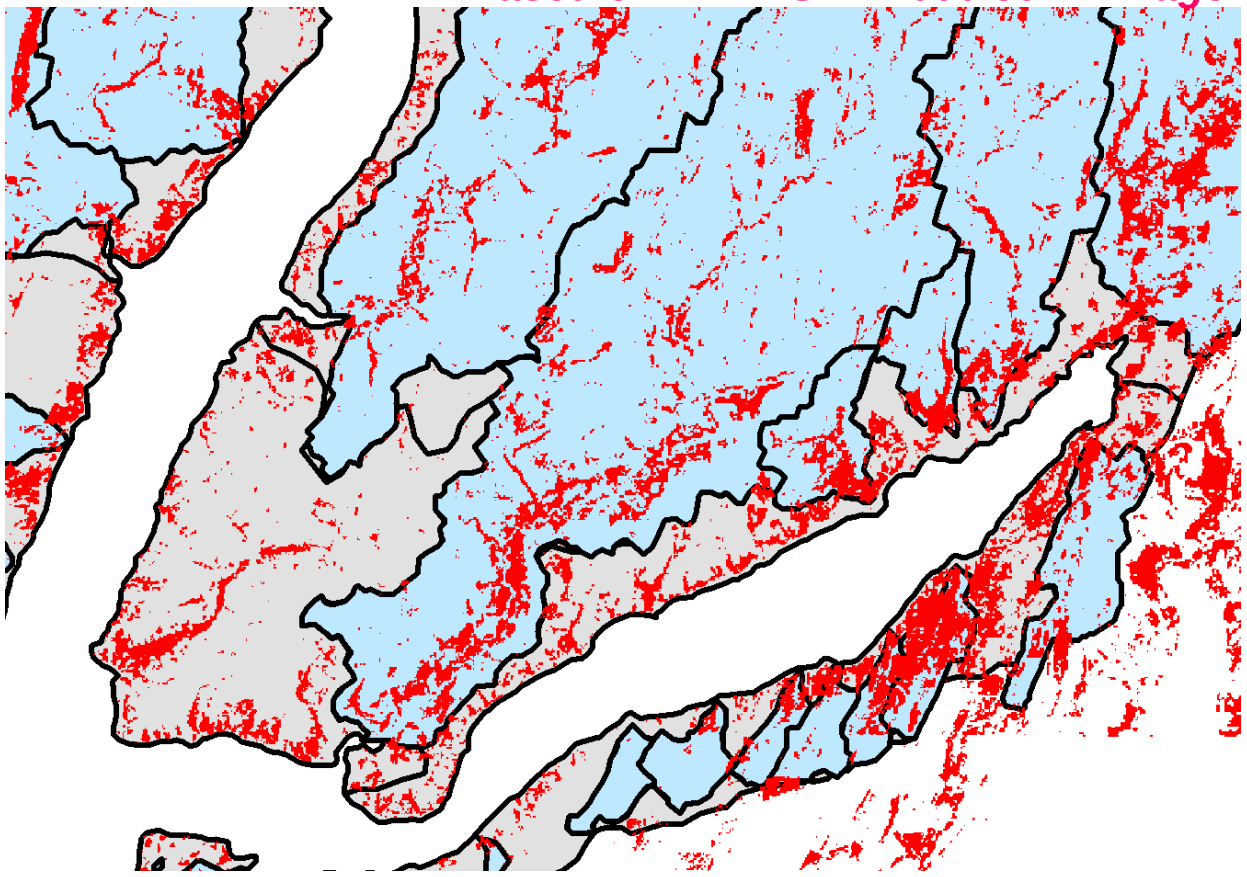
Parcel Data

3952 Residential parcels within 500m of shoreline



N-fixing red alder is an important component of forests along stream channels and floodplains (even in absence of human activity).

Based on LANDSAT 2000 30-m image

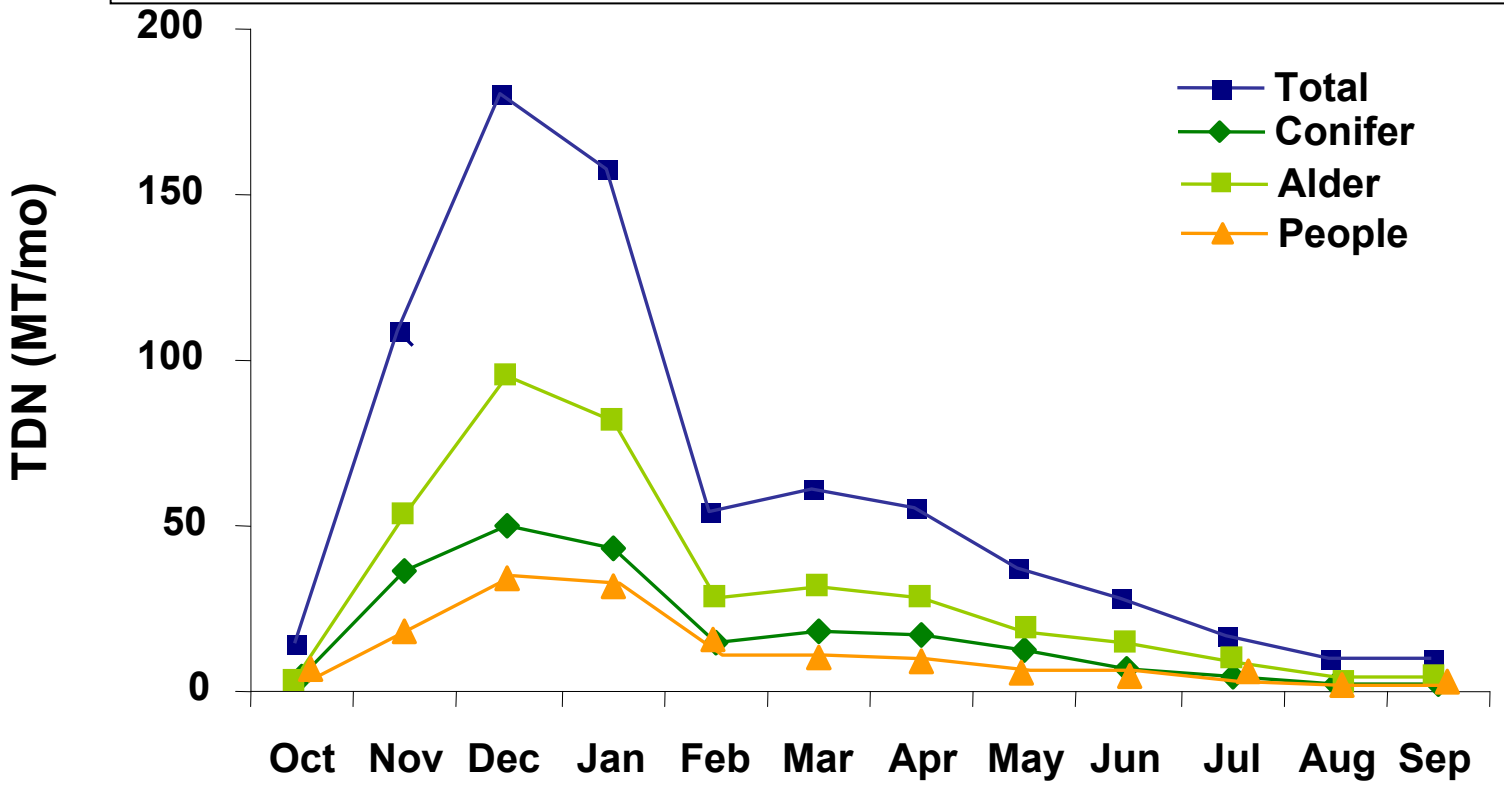


Scott Bechtold, Dan Hannifous, Lucy Hutrya et al.

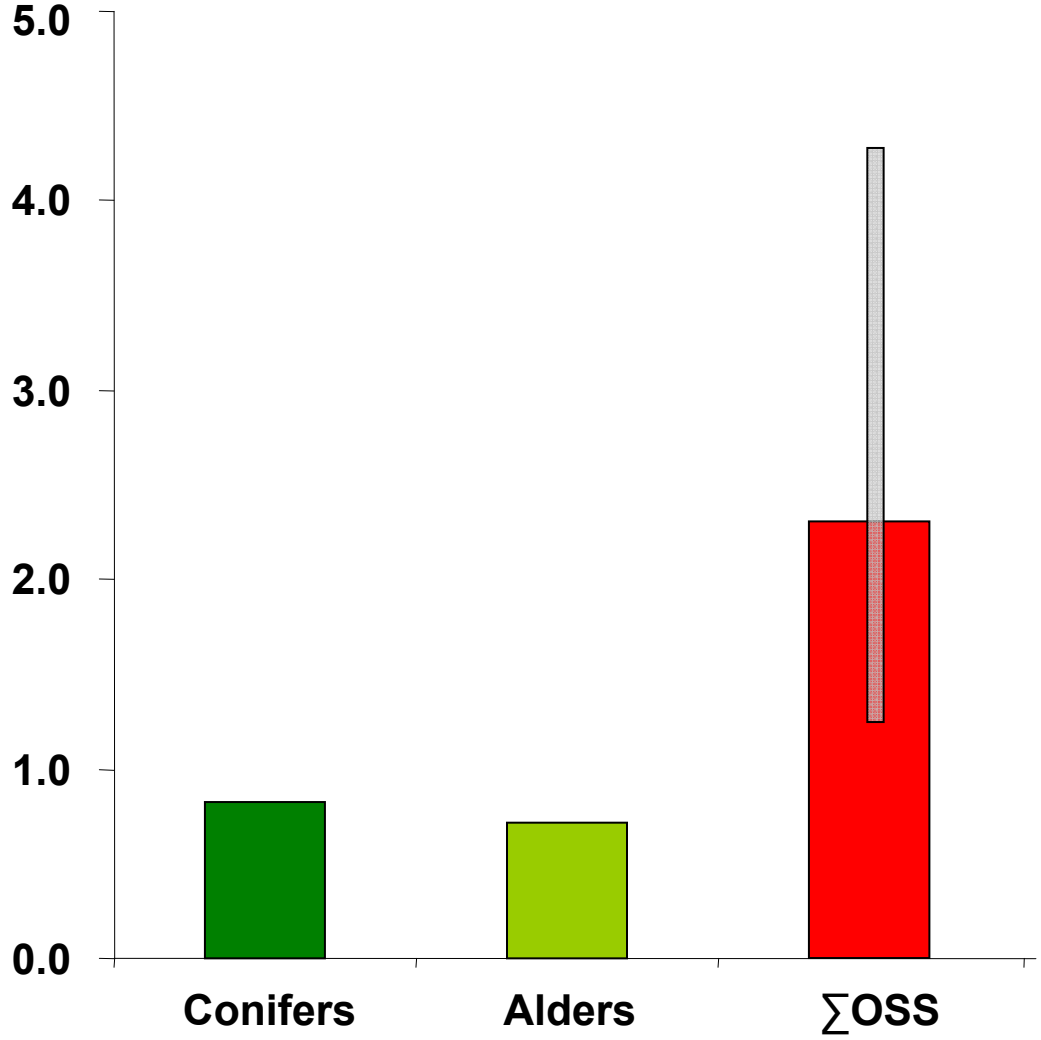
ENTIRE HOOD CANAL TOTAL TDN LOADING

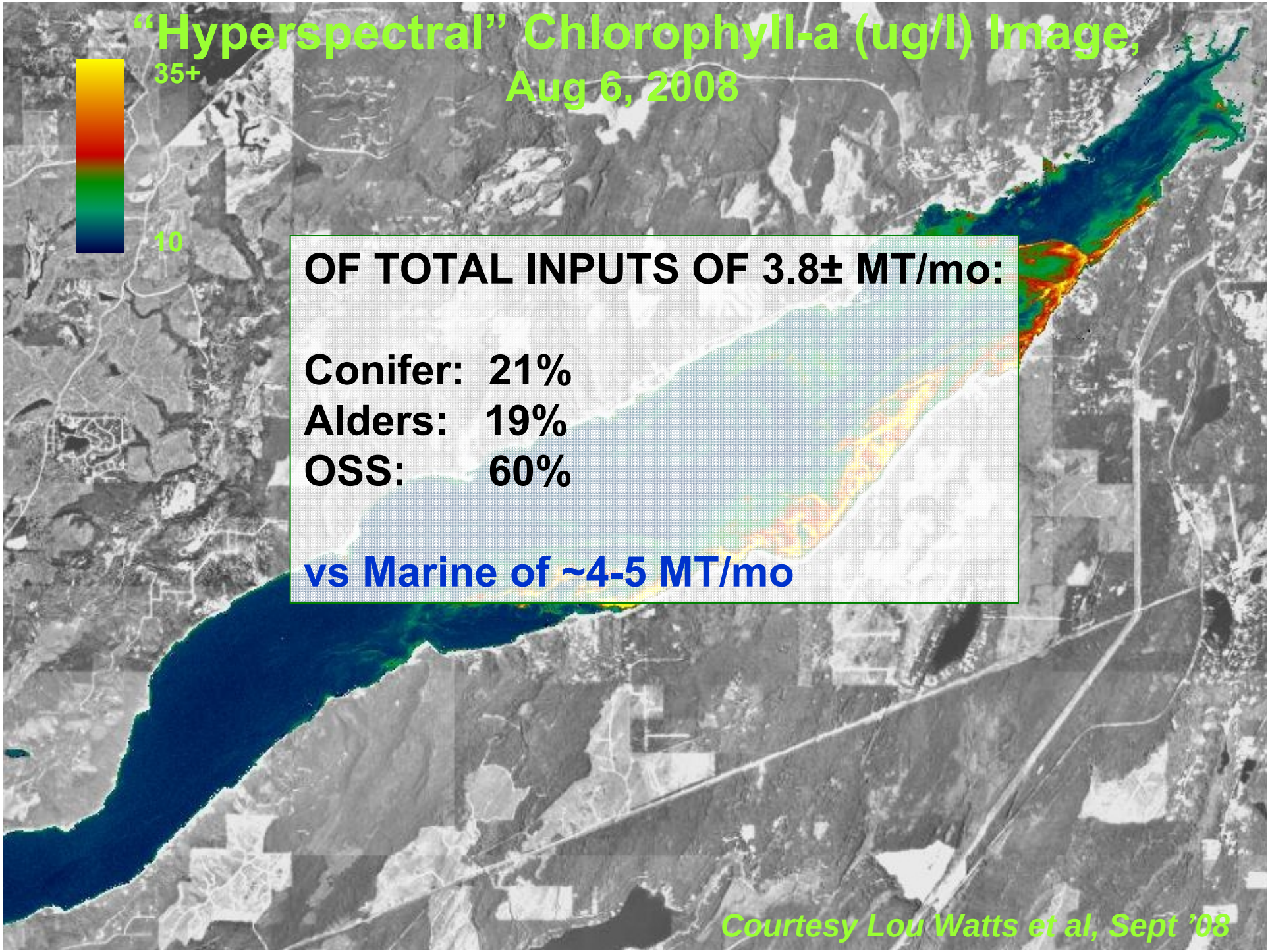
2005:
2006:
USGS
Water

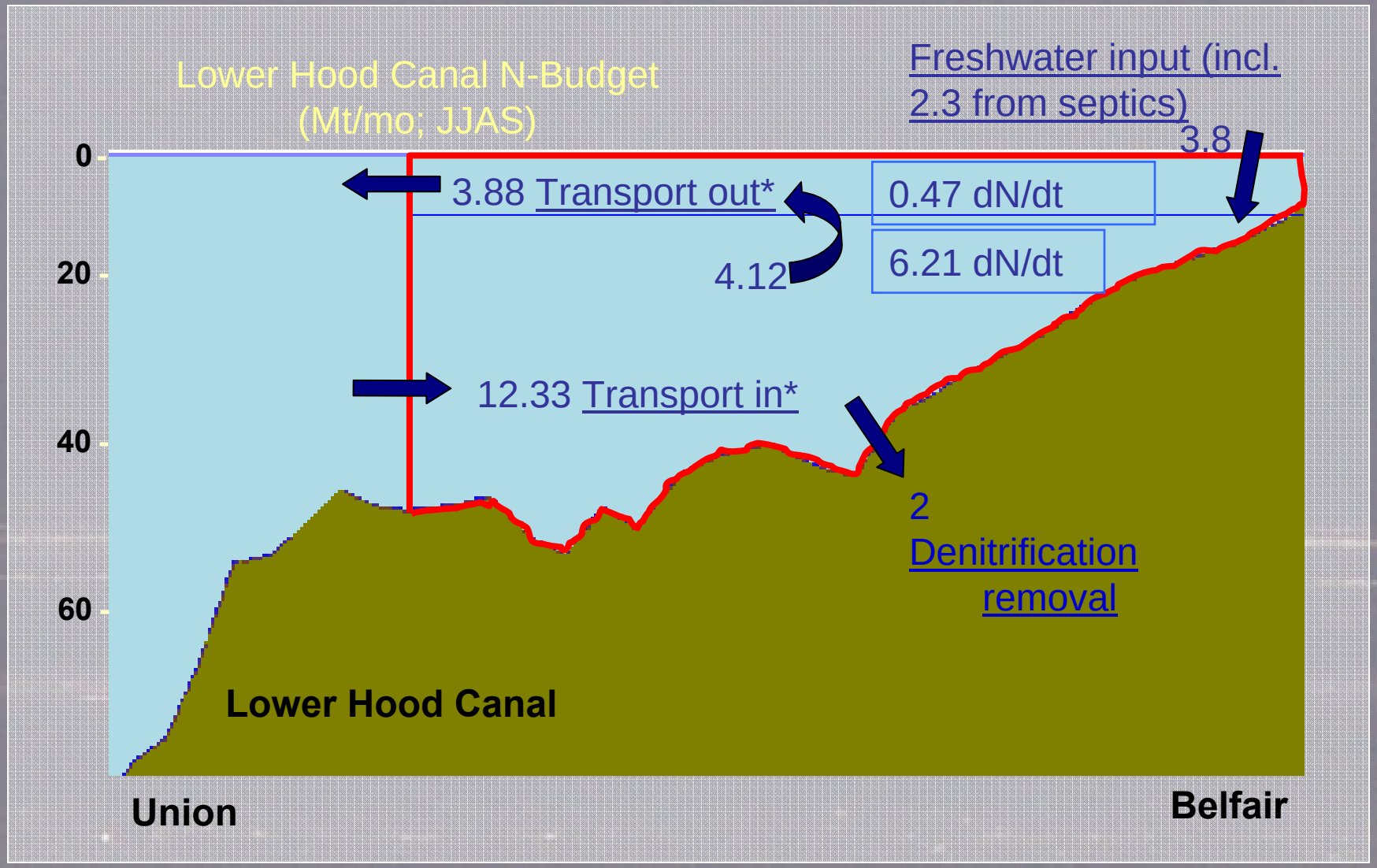
2007, OVERALL UPDATES – *IN PROGRESS*



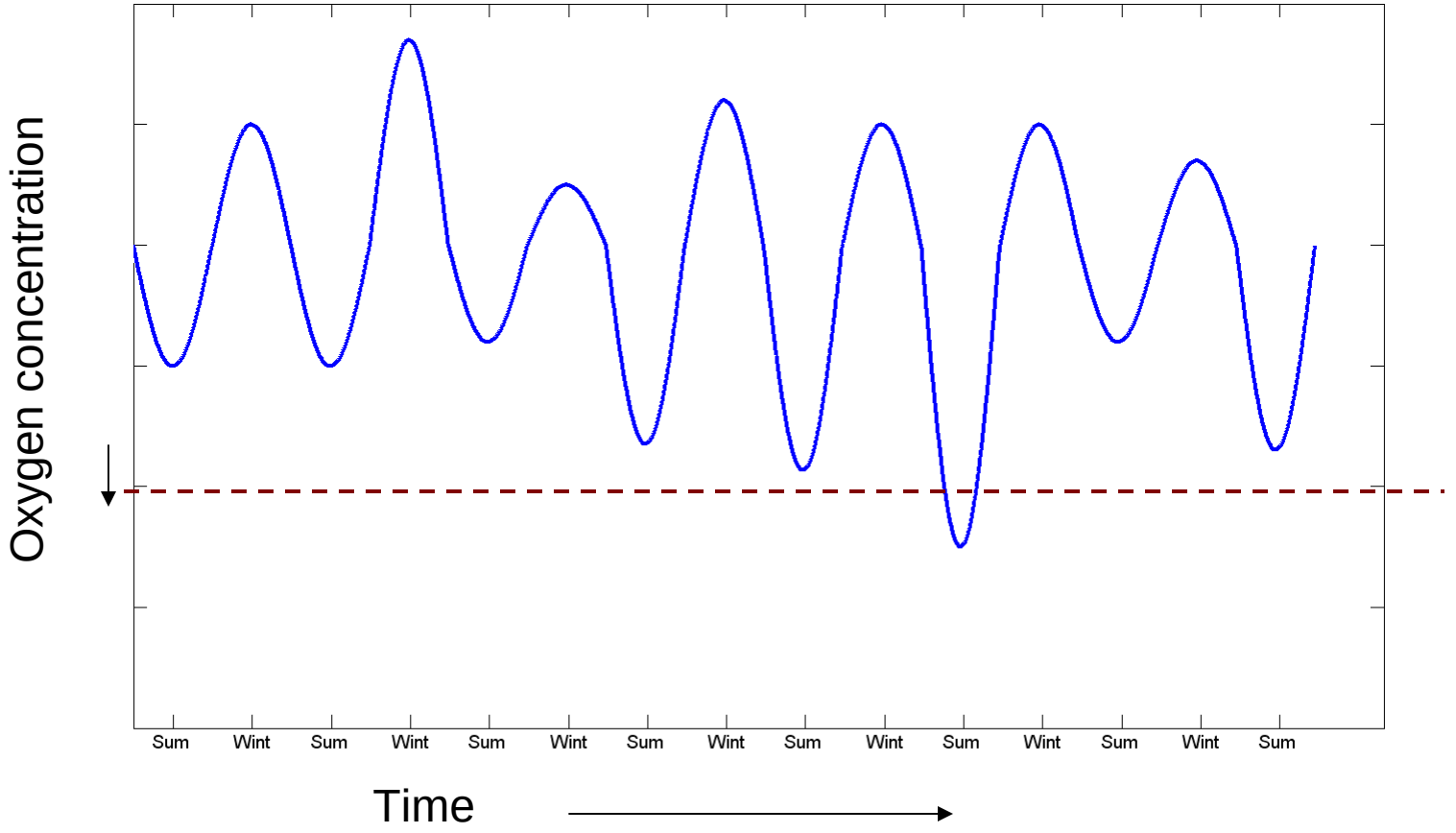
JUNE-SEPT
LIKELY RANGE TOTAL LYNCH COVE INPUT:
~3.8 MT/mo (2.7-5.8)




"Hyperspectral" Chlorophyll-a (ug/l) Image,
Aug 6, 2008
35+
10
OF TOTAL INPUTS OF 3.8± MT/mo:
Conifer: 21%
Alders: 19%
OSS: 60%
vs Marine of ~4-5 MT/mo
Courtesy Lou Watts et al, Sept '08


Lower Hood Canal N-Budget
(Mt/mo; JJAS)
Freshwater input (incl. 2.3 from septics)
3.8
0
20
40
60
3.88 Transport out*
0.47 dN/dt
4.12
6.21 dN/dt
12.33 Transport in*
2
Denitrification removal
Lower Hood Canal
Union
Belfair

- Hood Canal has naturally low oxygen with high interannual variation
- Oxygen concentration strongly affected by climate/ocean condition
- Human N load appears to have little influence on oxygen concentration on northern/central Hood Canal
- Human N load could cause lower oxygen concentration in Lower Hood Canal during summer
- Any reduction in oxygen increases risk of harm to biota



Important considerations

- Scale
  - *Regional (mainstem vs. lower HC)*
  - *Small vs. large (an OSS vs. lower HC)*
- Variability
  - Natural variation very large
- Uncertainty
  - Science ($p<0.01$, 0.05) vs.
    Policy (weight of evidence, or $p<0.49$)
- Future
  - Climate change & population growth

Why it matters…

Why it matters...to Hood Canal

HCDOP IAM results being communicated to Hood Canal Coordinating Council (Tribal Chairs and County Commissioners) and pertinent state agencies.

The scientific findings are being used to inform local decision-makers.

Our understanding of your questions

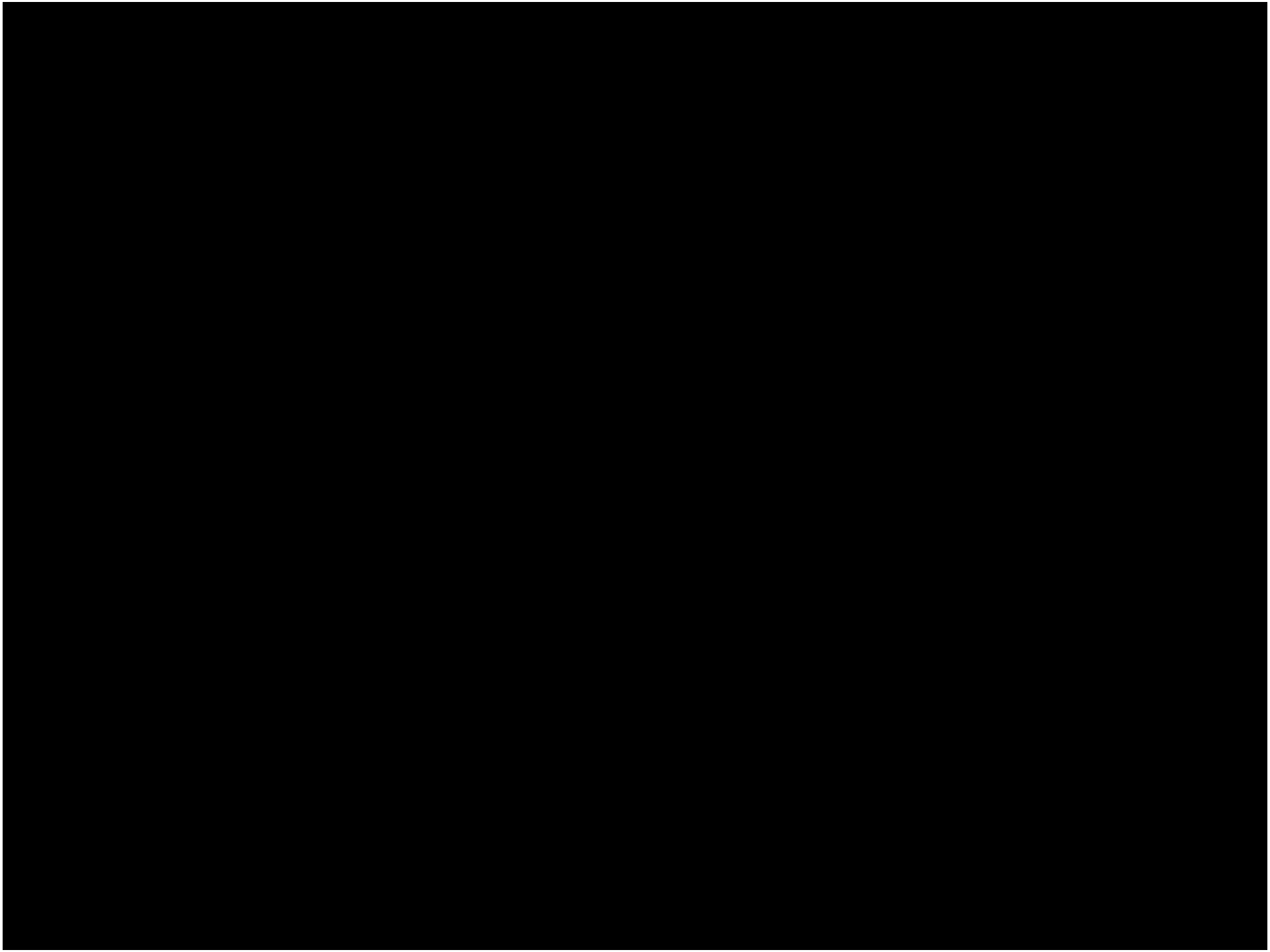
- What are the sources?
  - (Where? How much?)
- What is the impact?
  - on the ecosystem & is this a problem
  - on humans & is this a problem
- What to do?

HCDOP IAM Leads

- Watershed: Richey, **Turney**
  - **Bechtold**, Sheibley, Brett, Horowitz, Benjamin
- Marine: **Devol, Kawase**
  - Bhang, Alford, Mickett, Bassin, Ruef
- Biota: **Parker-Stetter**
  - Horne, Essington, Keister, Bargmann, Middleton, **Newton**

Y 5 Priorities

- Engage in dialog with HCCC and others
- Reduce scientific uncertainties
- Assess scenarios (e.g., growth, change)
- Assess sensitivities
- Sharpen tools that may aid decision-making
- Reporting

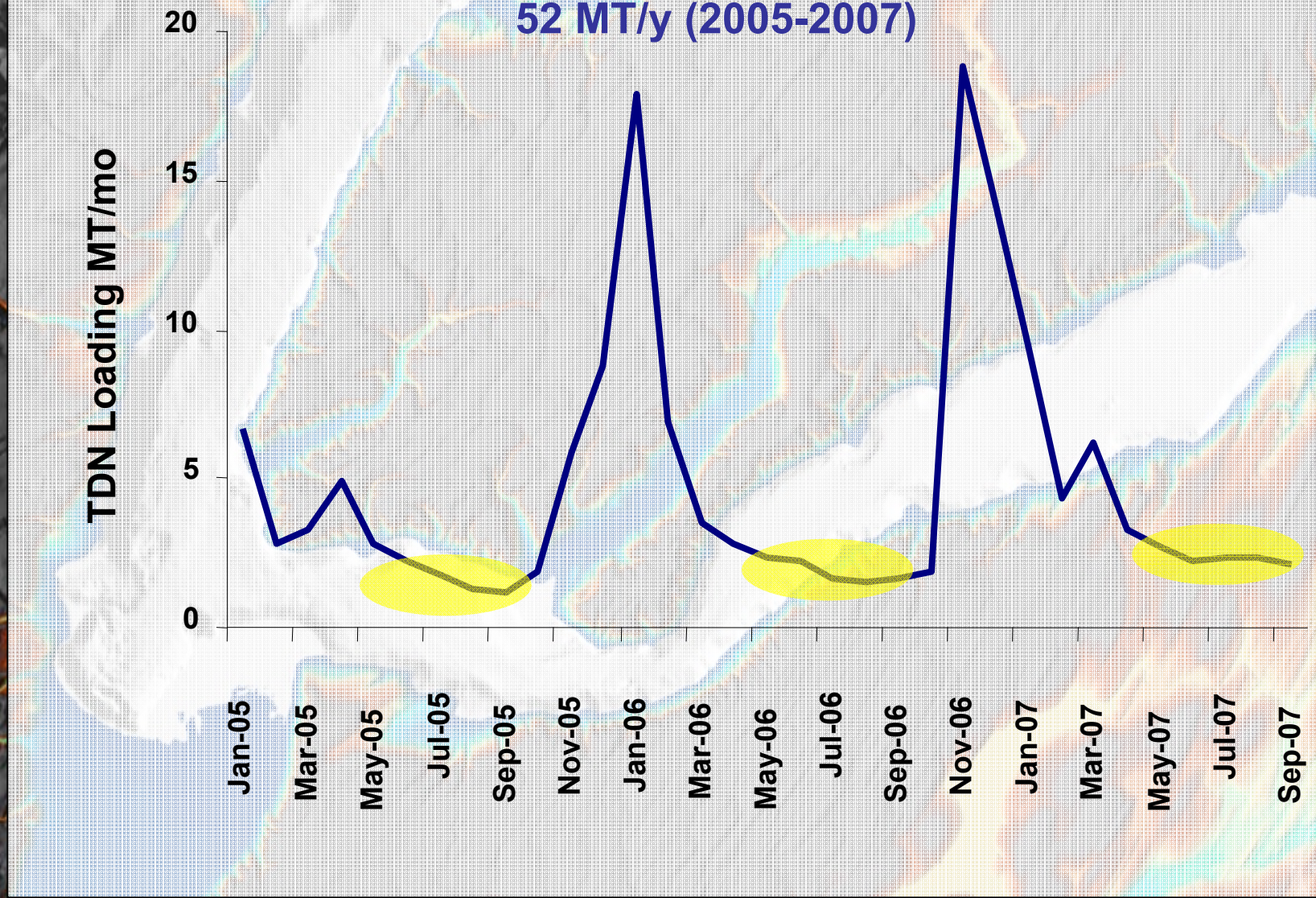


Why it matters...to the region

The HCDOP approach was effective because it:

- committed to research as well as no-regret actions at outset
- uses a system approach (basin, watershed, biota, humans, climate)
- has ability to partner across entities to conduct research
- has effective coordination among science and between science and management/policy
- involves local tribal, county, public community
- has strong outreach, availability of data
- has scientists willing to dialog with decision makers
- was granted funding for targeted research

LYNCH COVE TDN LOADING (DSEM*)



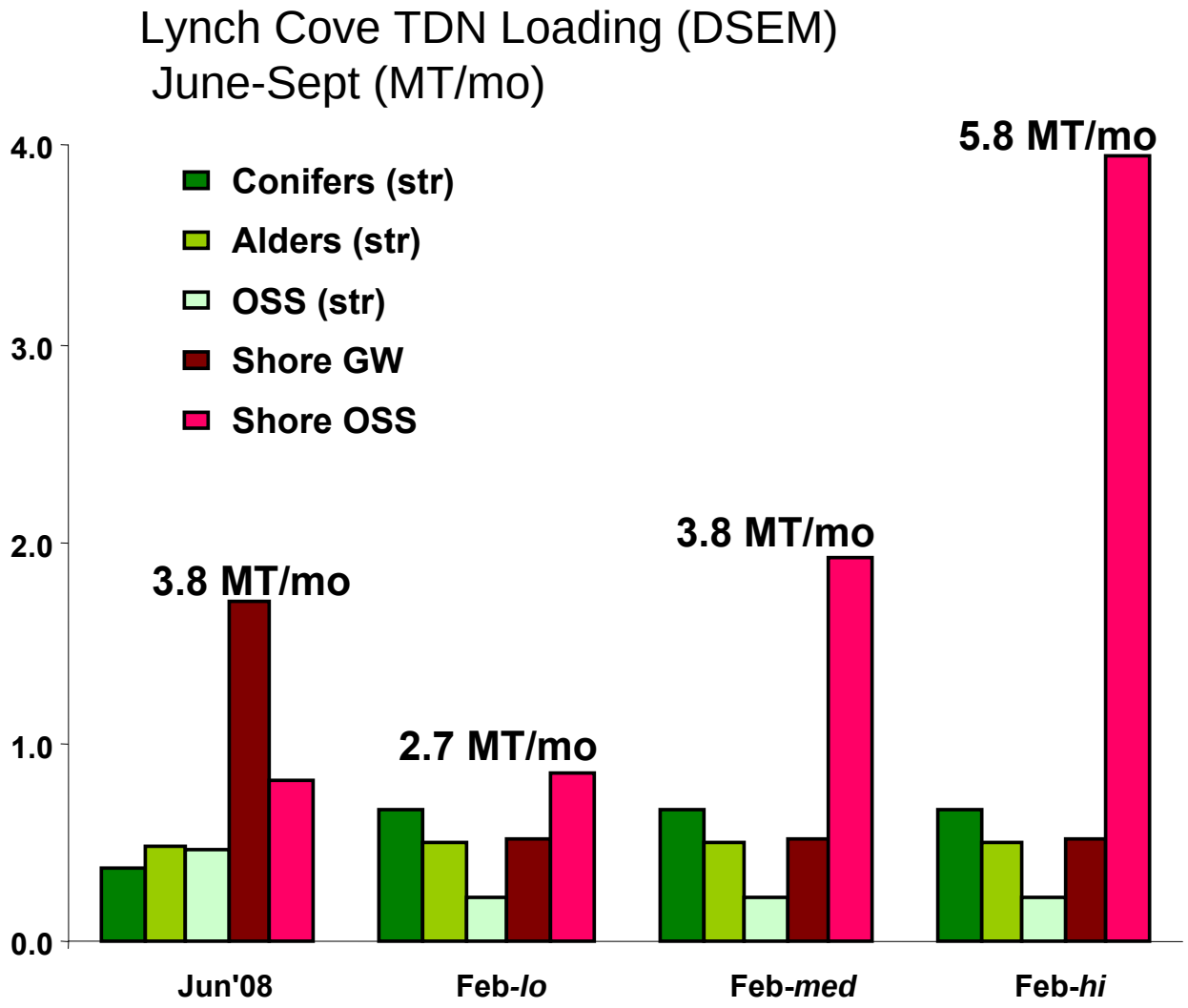
*Bechtold, Constans


But tough to make measurements
Groundwater/Seepage inputs to Lower Hood Canal,
August September (USGS)

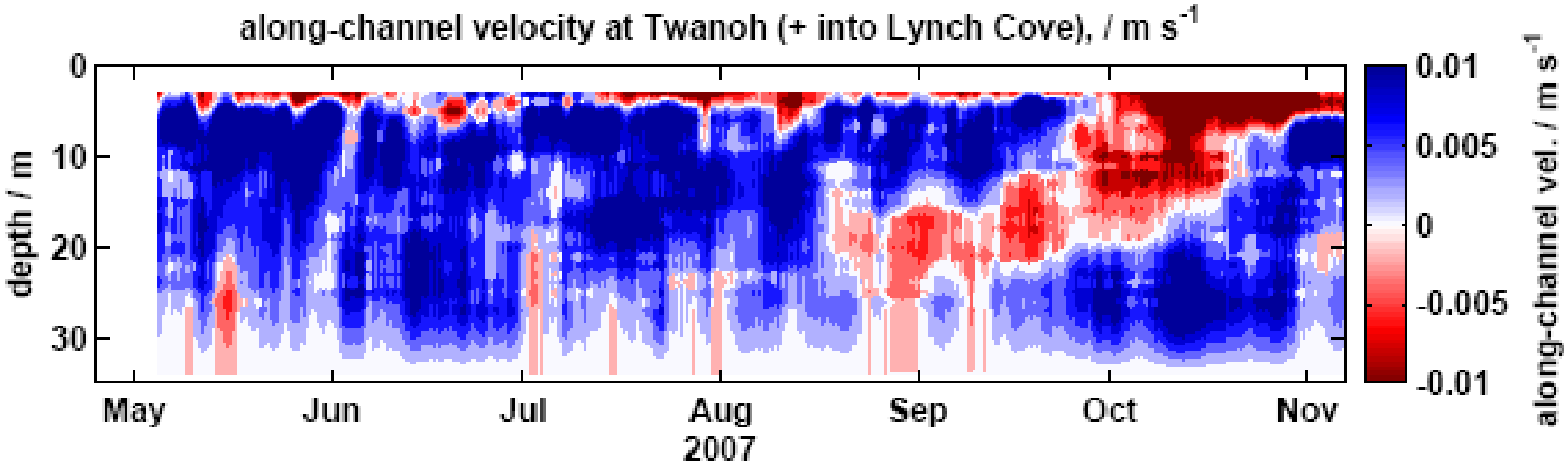
SCENARIOS FOR SHORELINE OSS: June-Sept

Housing Units x People/house x net N/person

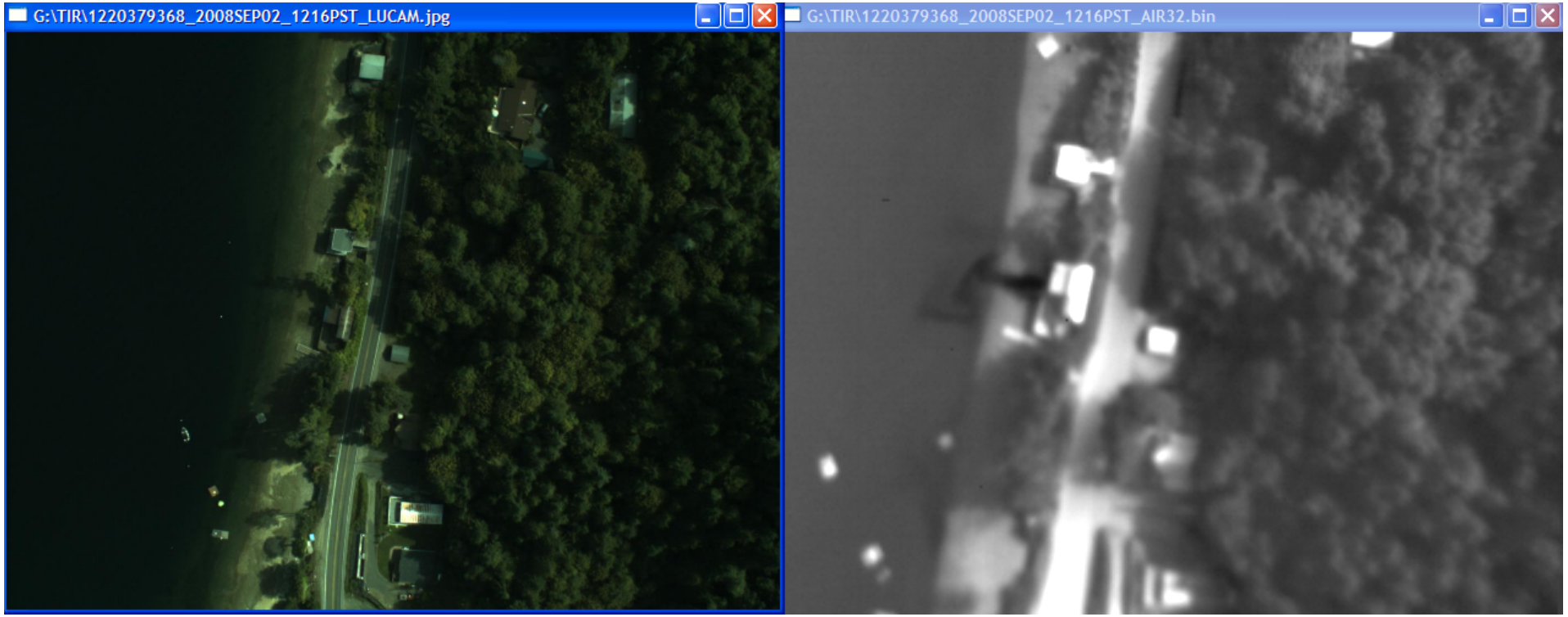
	#Units	Avg Pop	N/person
Case 1 (P)	1934	3427	2.95
Case 2	1934	5141	2.95
Case 3	1934	5141	4.5
Case 4	3952	10505	2.95
Case 5	3952	10505	4.5


Lynch Cove TDN Loading (DSEM)
June-Sept (MT/mo)
4.0
3.0
2.0
1.0
0.0
Conifers (str)
Alders (str)
OSS (str)
Shore GW
Shore OSS
3.8 MT/mo
2.7 MT/mo
3.8 MT/mo
5.8 MT/mo
Jun'08
Feb-lo
Feb-med
Feb-hi

Is anthropogenic stimulation of hypoxia only a relevant issue in Lower Hood Canal ?



Current meter data reveal a "squirt" of water (red) from Twanoh during mid-August to October, that goes out of Lower Hood Canal and travels toward Hoodsport.
This will export low oxygen water to the Hoodsport area.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